



Project Manual
Construction Documents

Volume 2 of 2

Coastal Engineering Building
UNC Wilmington
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Wilmington, North Carolina 28403

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DESIGN

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PART 1 - GENERAL

1.1 SCOPE

- A. Design, fabricate, install, and secure required approvals for a complete fire protection automatic sprinkler system where shown on the Drawings, as specified herein, and as needed for a complete and proper installation in accordance with pertinent requirements of NFPA 13, and local governmental agencies having jurisdiction.
- B. Work includes providing design services; furnishing all labor, material, equipment and installation as necessary and reasonably incidental to the proper completion and proper operation of the fire protection systems. The work shall consist of but shall not necessarily be limited to the following:
 - 1. Automatic wet-pipe sprinkler system as specified in Section 21 13 13.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 21 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 21 specifications contain statements more definitive or more restrictive.

1.3 DEFINITIONS

- A. Words and phrases used throughout the Contract Documents shall be interpreted as indicated below:
 - 1. Construction Documents – the basis for the work. It includes both the Drawings (plans) and Project Manual (specifications).
 - 2. Contractor – The person or organization awarded the contract for fire protection design and construction services.

In the case of a construction project administered as a multiple-prime contract, the term shall be further defined as the Contractor holding a prime contract for fire protection design and construction work.

The terms "Fire Protection Contractor" and "Sprinkler Contractor" may be used interchangeably with the term Contractor.

3. Provide – To furnish and install materials, equipment or systems.
4. Submittals – Submittals shall include Manufacturer's Catalog Data, Shop Drawings, Calculations, Certificates of Compliance, Testing Reports, Samples, and Operation and Maintenance Manuals.
5. Professional – The Architect and/or Engineer of record.
6. Work by Others – Work provided by a person or organization other than the Contractor.

1.4 CODES, REFERENCES, AND STANDARDS

- A. The Contractor shall comply with all laws, ordinances, and regulations of all Authorities Having Jurisdiction, including those of all applicable City, County, State, Federal and Public Utility entities. All licenses, permits, fees, inspection fees, etc., shall be obtained by the Contractor and the cost shall be included in the Contract price.
- B. The minimum standard of work under this contract shall be in accordance with the following model building codes and standards:
 1. International Code Council (ICC)
 - a. International Building Code with North Carolina Amendments
 - b. International Fire Prevention Code with North Carolina Amendments
 2. National Fire Protection Association
 - a. NFPA 13 – Standard for the Installation of Sprinkler Systems
 - b. NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances
 - c. NFPA 70 – National Electric Code
 3. North Carolina Department of Insurance (NCDOI)
 - a. Requirements for Automatic Sprinkler Systems, latest edition.
- C. Other publications listed throughout Division 22 form a part of this specification to the extent referenced. All publications shall be the latest edition as adopted by the Authority Having Jurisdiction. The publications are referred to in the text by basic designation only.

1.5 QUALITY ASSURANCE, WORKMANSHIP AND COORDINATION

- A. The Contractor must coordinate his work with that of the other trades so that all work will be performed in an orderly manner and with the least possible interference. Where coordination with other trades is required, the Professional shall make the final decision regarding changes to be made in the work.
- B. The Contractor must thoroughly familiarize himself with all specifications and drawings for the project so that he clearly understands his responsibility in relationship to the work to be performed. The Contractor must plan and perform his work to permit the use of the building as soon as possible.
 - 1. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.
- C. The Contractor shall guarantee the workmanship, materials and equipment, furnished against defects, leaks, performance and non-operation for a period of one (1) year after the date of final acceptance. Defective workmanship shall be construed as meaning defective materials and unsatisfactory installation and not intended to apply to ordinary wear and tear. The Contractor shall pay for any repairs or replacements caused by defective workmanship as construed herein within the period covered by the Guarantee, including all incidental work required to correct the deficiency.
- D. The Contractor shall expressly and completely follow all manufacturers' instructions required for validation of the manufacturer's warranty agreement including but not limited to service, maintenance and adjustments of the equipment.
- E. The Contractor will be held responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the Contract Documents.
 - 1. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 2. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.
- F. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

1.6 PROJECT RECORD DRAWINGS

- A. Deviations from the Contractor's approved Design and Fabrication Drawings necessary to coordinate the work with other trades, to conform to the building conditions or to conform to the rules and regulations of Authorities Having Jurisdiction shall be made only after obtaining written permission from the Professional.
- B. The Contractor shall keep a record of construction changes and deviations from the original Design and Fabrication Drawings. All changes shall be recorded on a separate set of prints which shall be kept at the job site specifically for that purpose. The record shall be made immediately after the work is completed. Documentation shall include:
 - 1. changes in pipe routing location
 - 2. valve locations
 - 3. Equipment locations, etc.
 - 4. actual capacities and values of equipment provided as indicated in equipment schedules
- C. The marked-up record set of drawings shall be submitted to the Professional for review and approval before final acceptance of the Fire Protection Contract work.

1.7 FIELD MEASUREMENTS

- A. Before ordering any equipment and material, or performing any work, the Contractor shall verify all measurements and dimensions at the job site and shall be held responsible for the correctness of same.
- B. No extra compensation will be allowed because differences between actual dimensions and measurements and those indicated on the Contractor's drawings.

1.8 PROTECTION OF SERVICES AND EQUIPMENT

- A. The Contractor, at his own expense, shall repair, replace and maintain in service any utilities, facilities or services (underground, aboveground, interior or exterior) damaged, broken, or otherwise rendered inoperative during construction due to activities on the part of the Contractor. The method used by the Contractor in repairing, replacing or maintaining the services shall be approved by the Professional.
- B. The Contractor shall protect, at his own expense, such of his work, materials or equipment that is subject to damage during the project duration. All openings into any piping, ducts or equipment must be securely covered, or otherwise protected, to prevent injury due to carelessly or maliciously dropped tools or materials, grit, dirt, or any foreign material. The Contractor shall be held responsible for all damage so done until his work is fully and finally accepted.

- C. It shall be the responsibility of the Contractor to protect motors, pumps, electrical equipment, and all similar items of equipment from dirt, grime, plaster, water, etc. during all phases of construction. This protection shall be provided by covering equipment with transparent plastic sheeting and/or locating the materials and equipment in an area free from the elements.

1.9 INTERRUPTION OF SERVICES

- A. The Contractor shall schedule his work to avoid any major interruption of any utility services.
- B. Existing utilities serving facilities occupied and used by the Owner or others shall not be interrupted except when such interruptions have been authorized in writing by the Owner or the Professional. Interruptions shall occur only after acceptable temporary utility services have been provided. The Contractor shall provide a minimum of ten (10) working days notice to the Professional and receive written notice to proceed before interrupting any utility.

1.10 CLEANUP

- A. The Contractor shall maintain buildings, grounds, and public properties free from accumulations of waste materials, debris and rubbish. At reasonable intervals during the progress of work, and when directed by the Owner's Authorized Representative, the site and public properties shall be cleaned and waste materials, debris and rubbish shall be disposed of in appropriate manner. The Contractor shall provide containers for collection of waste materials, debris and rubbish. Waste materials, debris and rubbish shall be removed from the job site and legally disposed of at a landfill area in accordance with all applicable regulations. Burning or burying waste materials, debris or rubbish on project site shall not be permitted.
- B. At the completion of the Project, remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed fire protection fixtures and equipment. Remove grease, dust, dirt, stains, labels, fingerprints and other foreign materials from sight-exposed fire protection fixtures and equipment. Broom clean paved and concrete surfaces; rake clean other ground surfaces. Repair, patch and touch up marred surfaces to specified finish or to match adjacent surfaces.

1.11 SUBMITTALS

- A. Submittals shall be in accordance with Division 01 of the Project Manual.
- B. General
 - 1. The Contractor shall provide to the Professional for review six (6) copies of required submittals, unless noted otherwise. All Catalog Data, Shop Drawings, Design (hydraulic) Calculations, and Certificates of Compliance shall be submitted as a single package. All delays to the job resulting from the Contractor's failure to provide submittals at one

time will be the responsibility of the Contractor. Four (4) copies will be returned to the Contractor.

2. Submittals provided for review shall clearly and completely describe the specific product(s) they represent. Where differences exist between the item specified and that submitted for review, the submittal shall be highlighted.
3. Shop Drawings shall be prepared by a Certified NICET Level III technician. The plans should bear the signature, stamp and certificate number of the technician.
4. Submittals shall bear the review stamp of the Contractor. The review stamp of the Contractor shall be affixed to shop drawings to indicate:
 - a. The Contractor has coordinated the electrical characteristics of the equipment.
 - b. The Contractor has verified that the equipment submitted will physically fit into the space allocated with adequate clearances for maintenance, access, and egress requirements.
 - c. The Contractor shall bear all associated costs that may accrue due to failure to completely represent a given product.
5. Material and equipment shown on the drawings or specified herein shall not be incorporated in the work of this Contract until shop drawings, hydraulic calculations, engineering data and catalog information have been reviewed and accepted by the Professional.
6. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable style or series designation.

C. Operation and Maintenance Manuals

1. Submit two (2) sets of 8-1/2" x 11" text sixty (60) days prior to operator training/pre-final inspection bound in three D side ring capacity expansion binders with durable plastic covers for review by the Professional.
2. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS – FIRE PROTECTION SYSTEMS", title of project, and subject matter of binder when multiple binders are required.
3. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
4. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified type on thirty (30) pound white paper.
 - a. Part 1: Directory, listing names, addresses, and telephone numbers of Contractor, Subcontractors, and equipment suppliers.
 - b. Part 2: Operation and maintenance instructions arranged by system or process flow and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

- 1) Significant design criteria.
- 2) List of equipment.
- 3) Parts list for each component.
- 4) Maintenance instructions for equipment and systems.
- 5) Maintenance instructions for finishes, including recommended cleaning methods and materials and operating instructions.
- 6) Special precautions identifying detrimental agents.
- 7) Special Requirements of other sections of this specification noted to be included in the operating and maintenance manual.
- 8) Original copy (reproductions will not be accepted) of NFPA 25 – Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.

c. Part 3: Project documents and certificates, including the following:

- 1) All approved Submittals
- 2) Shop Drawings
- 3) Hydraulic Calculations
- 4) Certificates of Compliance
- 5) Photocopies of warranties and bonds
- 6) Material safety data sheets

5. Submit two (2) copies of completed volumes in final form fifteen (15) days prior to owner training. These copies will include Professional's previous review comments.

1.12 ELECTRICAL EQUIPMENT

- A. The Contractor shall furnish all motors, combination starters/disconnects, overload protection and controls for equipment required to provide complete and workable systems, unless noted otherwise.
- B. All motors, motor control equipment and wiring shall meet the requirements of the National Electric Code and shall comply with the requirements of the Public Utility Company furnishing service and with the rules and regulations of all Authorities Having Jurisdiction.
- C. The Contractor shall verify electrical characteristics at the site before ordering electrical equipment.
- D. Motors under ½ (one-half) horsepower shall be 120 volts. Motors ½ (one-half) horsepower and over shall be 3 (three) phase. All motors to be 1750 revolutions per minute (rpm) unless noted otherwise. Combination motor starters shall be of the fused switch type complete with magnetic motor starter. Units shall be of the NEMA size and type applicable to motor size, with 3-pole overload. Overload elements and fuses shall be of the proper size to protect the motor. Unless noted otherwise, units shall be equipped with indicating lights, HAND-OFF-AUTOMATIC (HOA) selector switch, four (4) auxiliary contacts two (2) normally open (N.O.) and

two (2) normally closed (N.C.) and fused control transformer to provide 120-volt control voltage. Fusible disconnect switch operating handles shall be interlocked with the door so that the door cannot be opened with the switch in the "ON" position, except through a hidden release mechanism. The operating handle shall be arranged for padlocking in the "OFF" position with up to three padlocks. Fuses shall be furnished by the Contractor as required to comply with NEC requirements. Where R type fuses are indicated, fuse holders shall be provided with rejection clips. Equipment shall be Square D, Allen-Bradley, or General Electric or accepted substitute, and shall be provided with a NEMA Type 1 enclosure, unless noted otherwise.

1.13 CONTROL WIRING

- A. The Contractor shall provide all necessary control wiring and related conduit required for complete and workable systems.
- B. All conduit and wiring shall be in accordance with the latest edition of the National Electrical Code. Installation of control wiring shall be performed in a neat and workmanlike manner by competent workmen. Workmanship shall be as specified in Division 16.
- C. Control circuits shall be wired for 110-volt control, using fused individual control transformers. Circuits shall be fused and shall be interrupted when the disconnect device is opened.

1.14 INSPECTION AND TESTING

- A. General
 - 1. New fire protection systems and parts of existing systems which have been altered, extended or repaired shall be tested to disclose leaks and defects.
 - 2. The Contractor shall notify the Professional a minimum of 5 (five) working days prior to testing to coordinate the testing and inspection procedures.
 - 3. If the Professional determines that the fire protection systems do not pass the prescribed tests, then the Contractor shall be required to make the necessary repairs, at his own expense, and the Contractor shall re-inspect and re-test the systems. Repairing, inspection and testing shall be continued until all systems pass as determined by the Professional.
 - 4. All new, altered, extended or replaced fire protection shall be left uncovered and unconcealed until it has been inspected, tested and accepted by the Professional. Where such work has been covered or concealed before it has been inspected, tested and accepted, it shall be uncovered by the Contractor, at his own expense as directed by the Professional.
 - 5. All equipment, material, labor, etc., required for testing the fire protection systems shall be furnished by the Contractor.

1.15 INSTRUCTION OF THE OWNER

- A. After acceptance of the Project, the Contractor shall furnish the services of personnel thoroughly familiar with the completed installation to instruct the Owner in the proper operation and maintenance of all equipment and appurtenances provided.
- B. The Contractor shall provide the Owner with two weeks' notice before the instruction session.

1.16 CHASES AND OPENINGS

- A. All chases and openings required for the installation of the work shall be coordinated with the other trades. The Contractor shall provide the other trades with sufficient time (1 (one) week minimum) for coordination of all chases and openings. The contractor shall be responsible for all work required to cut and patch the required openings. The work shall be performed to the satisfaction of the Professional.
- B. Penetrations made in fire rated chases, partitions, floors, etc., shall be sealed with an approved material and method as required to maintain the integrity of the fire separation.
- C. The Contractor shall provide all sleeves, hangers, and anchors required for installation of work in chases and openings.

1.17 PAINTING

- A. Painting shall be in accordance with Division 09.

1.18 RELATED WORK

- A. All work related to providing complete fire protection systems and equipment shall be the responsibility of the Contractor. The following related work shall be provided as indicated in other specification Divisions, unless noted otherwise, but shall remain the responsibility of the Contractor for workmanship and completeness:
 - 1. General Contractor
 - a. Installation of access panels.
 - b. Final painting of existing walls, floors and ceilings where the surfaces are being refinished and remodeled under the General Contract. Refer to General Construction Drawings.
 - c. Concrete housekeeping pads for fire protection equipment.
 - 2. Electrical Contractor

- a. Verification of the proper rotation of three phase equipment and making modifications as required to correct improper rotation.
- b. Installation of all combination starters/disconnects and overload protectors.

1.19 MISCELLANEOUS STEEL AND ACCESSORIES

- A. The contractor shall provide all necessary steel angles, channels, pipe, rods, nuts, bolts, etc., as shown on plans, as specified, or as may be required for complete and proper installation of sprinkler piping, systems and equipment. All material and workmanship shall be of the best quality and shall be installed in accordance with the best practices of the trade.

1.20 ACCESS PANELS

- A. The Contractor shall furnish access doors to the General Contractor for installation in ceilings, walls, partitions and floors for access to valve and other appurtenances.
- B. Access panels shall be of sufficient size to permit removal or access to equipment, except that the minimum size shall be 12-inches by 16-inches.
- C. Access door locations shall be as determined by field conditions for optimum access to equipment, and shall be reviewed by the Professional before final installation
- D. Access doors shall be suitable for installation in the finish material of the ceilings, walls, partitions and floors.
- E. Frame and panel access doors in restrooms, kitchens and as indicated shall be stainless steel.
- F. Access doors with UL Listing shall be provided in rated construction assemblies. Access doors shall be "B-Label" and shall have a UL one and one-half (1-1/2) hour rating at 250 degrees F rating for both door and frame. Maximum size shall be 20" x 20" or 400 square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), continuous type hinge on one side, flush-face type lock with key operation and self-latching cylinder locks.
- G. Access doors without UL label shall be provided in all non-rated construction assemblies: Frame shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges and flush-face type lock with key operation and self-latching cylinder locks. Door shall open 175 degrees (minimum).
- H. All access doors shall be keyed alike.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials used on fire protection systems shall meet the requirements of applicable codes, standards, and requirements of Local Authorities Having Jurisdiction and the Owner's Insurance Carrier.

2.2 SPRINKLER AND STANDPIPE PIPING, ABOVE GROUND

- A. Piping: black steel meeting ASTM A53, ASTM A135, or ASTM A795.
1. Piping 2-½" and larger shall be Schedule 10 or the approximately equal "flow" products with roll-grooved, flanged or welded connections.
 2. Piping 2" and smaller shall be Schedule 40 with threaded or welded connections.
 3. Piping shall be hot-dipped galvanized with two coats of epoxy paint where specified herein or noted on the drawings. Architect to select color.
- B. Fittings: UL-listed, standard weight suitable for pressures up to 250 psig, cast iron meeting ASTM A126 or malleable iron meeting ASTM A197. Threaded cast iron fittings shall meet ANSI B16.4; flanged cast iron fittings shall meet ANSI B16.1. Threaded malleable iron fittings shall meet ANSI B16.3. Grooved fittings and couplings shall be UL-listed and shall be of ductile iron meeting ASTM A536, utilizing an EDPM gasket. Fittings shall be short pattern, with flow equal to standard pattern fittings. Plain-end fittings and couplings or welded-segmented fittings shall not be used. Changes in pipe diameter shall be made using tapered reducing fittings. Bushings or grooved end reducing couplings shall not be used unless standard reducing fittings are not regularly available.
1. Grooved joint couplings shall be:
 - a. Rigid Type: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with NFPA-13. Couplings shall be fully installed at visual pad-to-pad offset contact. (Tongue and recess type couplings, or any coupling that requires exact gapping of bolt pads on each side of the coupling at specified torque ratings, are not allowed.)
 - 1) 1-½" through 4": Installation-Ready, for direct stab installation without field disassembly. Victaulic Style 009-EZ.
 - 2) Victaulic FireLock™ Style 005 or Zero-Flex Style 07.
 - b. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for seismic applications. Victaulic Style 75 or 77.
 2. Gaskets:

Fire Protection Service	Temp. Range	Gasket Recommendation
Dry Systems	Ambient	FlushSeal®, Grade EPDM, Type A
Freezer Applications	-40°F to 0°F	FlushSeal®, Grade L, Silicone
Water/Wet Systems	Ambient	Grade EPDM, Type A

2.4 VALVES FOR FIRE PROTECTION SYSTEMS

- A. Gates Valves: Class 125, comply with MSS SP-80, bronze body, screwed bonnet, rising stem, solid wedge. 3" and larger; comply with MSS SP-70, iron body, bronze trim, rising stem, hand wheel, OS&Y, flanged or grooved ends.
- B. Butterfly Valves:
 - 1. Comply with MSS SP-67, lug type, cast or ductile iron body, chrome plated ductile iron disk, EPDM seat, extended neck, handwheel and gear drive and integral indicating device, built-in tamper proof switch, 200 PSI rating.
 - 2. Grooved end type with ductile iron body, EPDM coated ductile iron disk with integrally cast stem, handwheel and gear drive and integral indicating devices, with weatherproof actuator and supervisory switches, 300 PSI rating.
- C. Spring-Actuated Check Valves: 250 PSI rating, grooved end ductile iron one-piece body, stainless steel spring and shaft, suitable for vertical or horizontal installations.
- D. Check Valves: Class 125, comply with MSS SP-80 bronze body, screwed cap. "Y" pattern swing, bronze disc. 3" and larger, comply with MSS SP-71, class 125, iron body, bronze mounted, horizontal swing, cast iron disc.

2.5 DRAIN VALVES

- A. Provide bronze compression stop with hose thread nipple and cap.

PART 3 - EXECUTION

3.1 GENERAL

- A. All materials and equipment used shall be installed in strict accordance with the Standards under which the materials are accepted and approved, and in strict accordance with the manufacturer's instructions.
- B. The Contractor's Drawings shall indicate every bend, offset, change in direction and appurtenance required to provide a complete and workable system.
- C. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Gaskets shall be of an elastomer grade suitable for the intended service and shall be molded and produced by the coupling

manufacturer. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

END OF SECTION 21 0500

SECTION 21 1313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes wet-pipe sprinkler system guidelines for system design, installation, and certification.
- B. Related Sections:
 - 1. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections to equipment specified by this section.

1.2 REFERENCES

- A. National Fire Protection Association:
 - 1. NFPA 13 - Installation of Sprinkler Systems.

1.3 SYSTEM DESCRIPTION

- A. System to provide coverage for entire building.
- B. Provide a hydraulically designed system to NFPA 13 occupancy requirements.
- C. Obtain up-to-date flow test data. Determine volume and pressure of incoming water supply from water flow test data. Provide flow test data on the Shop Drawings.
- D. Interface sprinkler system with building fire and smoke alarm system.
- E. For new systems, provide fire department connections as indicated on Drawings.

1.4 PERFORMANCE REQUIREMENTS

- A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
- B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated
 - 1. Provide fire-hydrant flow test records to indicate the following conditions:
 - a. Time of test
 - b. Name and Company of person performing the test
 - c. Location of Residual Fire Hydrant
 - d. Location of Flow Fire Hydrant
 - e. Static Pressure at Residual Fire Hydrant

- f. Measured Flow at Flow Fire Hydrant
 - g. Residual Pressure at Residual Fire Hydrant
- C. Sprinkler system design shall be approved by authorities having jurisdiction.
 - 1. Margin of Safety for Available Water Flow and Pressure: 10 psi less static, 10 psi less residual pressure and 10% less flow.
 - 2. Recommended Sprinkler Occupancy Hazard Classifications:
 - a. As noted on Contract Documents.
 - 3. Recommended Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
 - 4. Maximum Protection Area per Sprinkler: Per UL listing.
 - 5. Total Combined Hose-Stream Demand Requirement: Per NFPA 13 unless otherwise indicated:
 - a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
 - b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

1.5 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Provide layout of finished ceiling areas indicating sprinkler locations coordinated with ceiling installation and the work of other trades (ductwork, lights and any other ceiling mounted devices). Show detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
- C. Product Data: Submit data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- D. Design Data: Submit design calculations signed and sealed by a NICET Level 3 or higher professional.
- E. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

1.6 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.

- B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and inspector's test locations.
- C. Operation and Maintenance Data: Submit components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.7 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 13.

1.8 QUALIFICATIONS

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

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Product storage and handling requirements.
- B. Store products in shipping containers until installation.
- C. Furnish piping with temporary inlet and outlet caps until installation.

1.10 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. Furnish five (5) year manufacturer warranty for system components.

1.11 EXTRA MATERIALS

- A. Division 01 - Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish extra sprinklers under provisions of NFPA 13.
- C. Furnish suitable wrenches for each sprinkler type.
- D. Furnish metal storage cabinet in location designated by Architect, adjacent to system riser.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Suspended Ceiling Type:
 - 1. Type: Concealed pendant type with coverplate.
 - 2. Color of Coverplate: Coordinate color with architect.
 - 3. Fusible Link: temperature rated for specific area hazard.
- B. Exposed Area Type:
 - 1. Type: Standard upright type.
 - 2. Finish: Brass.
 - 3. Fusible Link: temperature rated for specific area hazard.
- C. Side wall Type:
 - 1. Type: Recessed horizontal side wall type with matching escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
- D. Provide corrosion resistant sprinkler heads where indicated on drawings.
- E. Guards: Finish to match sprinkler finish.

2.2 PIPING SPECIALTIES

- A. Wet Pipe Sprinkler Riser Check Valve: Ductile iron body, swing check type valve with brass seat and rubber-faced or aluminum-bronze clapper with elastomer seal. Provide complete with main drain valve and pressure gauges. Rated for 250 psi working pressure. Valve internal components shall be replaceable without removing from the installed position.
- B. Electric Alarm: Electrically operated gong with pressure alarm switch.
- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125-volt AC and 2.0 amp at 24-volt DC.
- D. Fire Department Connections:
 - 1. Free standing type provided by Site Utility Contractor.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 13.

- B. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent fire department connectors to allow full swing of fire department wrench handle.
- C. Locate outside alarm-gong on building wall as indicated on Drawings.
- D. Place pipe runs to minimize obstruction to other work.
- E. Install piping in concealed spaces above finished ceilings.
- F. Center sprinklers in two directions in ceiling tile and install piping offsets.
 - 1. A stainless-steel flexible drop system may be used to properly locate sprinkler heads. The drop system shall be supplied with required supporting members and bracing. Drop System shall be provided with braided jacket, un-braided systems will not be accepted.
- G. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
- H. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.
- I. Install guards on sprinklers where required to protect sprinklers from physical damage.
- J. Hydrostatically test entire system.
- K. Require test be witnessed by authority having jurisdiction.

3.2 INTERFACE WITH OTHER PRODUCTS

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

3.3 CLEANING

- A. Section 01 70 00 - Execution and Closeout Requirements: Final cleaning.
- B. Flush entire piping system of foreign matter.

3.4 PROTECTION OF INSTALLED CONSTRUCTION

- A. Section 01 70 00 - Execution and Closeout Requirements: Protecting installed construction.
- B. Apply masking tape or paper cover to protect concealed sprinklers, cover plates, and sprinkler escutcheons not receiving field paint finish. Remove after painting. Replace painted sprinklers with new.

END OF SECTION 21 1313

SECTION 22 0500 - PLUMBING GENERAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 22 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 22 sections contain statements more definitive or more restrictive.

1.2 SCOPE

- A. Provide all labor, material, equipment and services necessary and reasonably incidental to the proper completion and proper operation of the building plumbing systems. The work shall consist of but shall not necessarily be limited to the following:
 - 1. Domestic water system including extension of piping and connections to all fixtures and/or equipment. The domestic water system shall be extended from a point 5 (five) feet beyond the exterior face of the building.
 - 2. Sanitary drain, waste and vent system including extension of piping and connection to all fixtures and/or equipment. The sanitary system shall be extended to a point 5 (five) feet beyond the exterior face of the building.

1.3 DEFINITIONS

- A. Words and phrases used throughout the Contract Documents shall be interpreted as indicated below:
 - 1. Construction Documents – the basis for the work. It includes both the Drawings (plans) and Project Manual (specifications).
 - 2. Contractor – The person or organization awarded the contract for construction services.

In the case of a construction project administered as a multiple-prime contract, the term shall be further defined as the Contractor holding a prime contract for plumbing construction work.

The term “Plumbing Contractor” is used interchangeably with the term “Contractor”.
 - 3. Provide – To furnish and install materials, equipment or systems.

4. Submittals – Submittals shall include Manufacturer’s Catalog Data, Shop Drawings, Calculations, Certificates of Compliance, Testing Reports, Samples, and Operation and Maintenance Manuals.
5. Professional – The Architect and/or Engineer of record.
6. Work by Others – Work provided by a person or organization other than the Contractor.

1.4 CODES, REFERENCES AND STANDARDS

- A. The Contractor shall comply with all laws, ordinances, and regulations of all Authorities Having Jurisdiction, including those of all applicable City, County, State, Federal and Public Utility entities. All licenses, permits, fees, connection fees, tapping fees, inspection fees, etc., shall be obtained by the Contractor and the cost shall be included in the Contract price.
- B. The minimum standard of work under this contract shall be in accordance with the following model building codes:
 1. North Carolina State Building Codes 2018 Edition:
 - a. North Carolina State Building Code.
 - b. North Carolina State Plumbing Code.
 - c. North Carolina State Mechanical Code.
 - d. North Carolina State Fire Prevention Code.
 - e. North Carolina State Fuel Gas Code.
 - f. North Carolina State Energy Code.
- C. Other publications listed throughout Division 22 form a part of this specification to the extent referenced. All publications shall be the latest edition as adopted by the Authority Having Jurisdiction. The publications are referred to in the text by basic designation only.

1.5 QUALITY ASSURANCE, WORKMANSHIP AND COORDINATION

- A. The Contractor must coordinate his work with that of the other trades so that all work will be performed in an orderly manner and with the least possible interference. Where coordination with other trades is required, the Professional shall make the final decision regarding changes to be made in the work.
- B. The Contractor must thoroughly familiarize himself with all the Construction Documents for the project so that he clearly understands his responsibility in relationship to the work to be performed. The Contractor must plan and perform his work to permit the use of the building as soon as possible.

- C. The Contractor shall guarantee the workmanship, materials, and equipment, furnished against defects, leaks, performance and non-operation for a period of one (1) year after the date of final acceptance. Defective workmanship shall be construed as meaning defective materials and unsatisfactory installation and not intended to apply to ordinary wear and tear. The Contractor shall pay for any repairs or replacements caused by defective workmanship as construed herein within the period covered by the Guarantee, including all incidental work required to correct the deficiency.
- D. The Contractor shall expressly and completely follow all manufacturers' instructions required for validation of the manufacturer's warranty agreement including but not limited to service, maintenance and adjustments of the equipment.
- E. The Contractor shall be held responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the Contract Documents.

1.6 PROJECT RECORD DRAWINGS

- A. Changes from the Contract Drawings necessary to coordinate the work with other trades, to conform to the building conditions or to conform to the rules and regulations of Authorities Having Jurisdiction shall be made only after obtaining written permission from the Professional.
- B. The Contractor shall keep a record of construction changes and deviations from the original Contract Drawings. All changes shall be recorded on a separate set of prints which shall be kept at the job site specifically for that purpose. The record shall be made immediately after the work is completed. Documentation shall include:
 - 1. location and elevation of new and existing utility lines
 - 2. points of connection to existing utility lines
 - 3. changes in pipe routing location
 - 4. valve locations
 - 5. equipment locations, etc.
 - 6. actual capacities and values of equipment provided as indicated in equipment schedules
- C. The marked-up record set of drawings shall be delivered to the Professional before final acceptance of the Plumbing Contract work.

1.7 FIELD MEASUREMENTS

- A. It shall be the Contractor's responsibility to verify the location of any and all existing underground utilities in the vicinity of his work. When it has been indicated that these

utilities are to remain in place, the Contractor shall provide adequate means of support and protection during excavation operations.

- B. Before ordering any equipment and material, or performing any work, the Contractor shall verify all measurements and dimensions at the job site and shall be held responsible for the correctness of same.
- C. No extra compensation will be allowed because differences between actual dimensions and measurements and those indicated on the drawings.
- D. Any difference which may be found shall be submitted to the Professional for consideration before proceeding with the work.

1.8 PROTECTION OF SERVICES AND EQUIPMENT

- A. The Contractor, at his own expense, shall repair, replace and maintain in service any utilities, facilities or services (underground, aboveground, interior or exterior) damaged, broken, or otherwise rendered inoperative during construction due to activities on the part of the Contractor. The method used by the Contractor in repairing, replacing or maintaining the services shall be approved by the Professional.
- B. The Contractor shall protect, at his own expense, such of his work, materials or equipment that is subject to damage during the project duration. All openings into any piping, ducts or equipment must be securely covered, or otherwise protected, to prevent injury due to carelessly or maliciously dropped tools or materials, grit, dirt, or any foreign material. The Contractor shall be held responsible for all damage so done until his work is fully and finally accepted.
- C. It shall be the responsibility of the Contractor to protect motors, pumps, electrical equipment, and all similar items of equipment from dirt, grime, plaster, water, etc. during all phases of construction. This protection shall be provided by covering equipment with transparent plastic sheeting and/or locating the materials and equipment in an area free from the elements.

1.9 INTERRUPTION OF SERVICES

- A. The Contractor shall schedule his work to avoid any major interruption of any utility services.
- B. Existing utilities serving facilities occupied and used by the Owner or others shall not be interrupted except when such interruptions have been authorized in writing by the Owner or the Professional. Interruptions shall occur only after acceptable temporary utility services have been provided. The Contractor shall provide a minimum of ten (10) working days notice to the Professional and receive written notice to proceed before interrupting any utility.

1.10 CLEANUP

- A. The Contractor shall maintain buildings, grounds and public properties free from accumulations of waste materials, debris and rubbish. At reasonable intervals during the progress of work, and when directed by the Owner's Authorized Representative, the site and public properties shall be cleaned and waste materials, debris and rubbish shall be disposed of in appropriate manner. The Contractor shall provide containers for collection of waste materials, debris and rubbish. Waste materials, debris and rubbish shall be removed from the job site and legally disposed of at a landfill area in accordance with all applicable regulations. Burning or burying waste materials, debris or rubbish on project site shall not be permitted.
- B. At the completion of the Project, remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed plumbing fixtures and equipment. Remove grease, dust, dirt, stains, labels, fingerprints and other foreign materials from sight-exposed plumbing fixtures and equipment. Broom clean paved and concrete surfaces; rake clean other ground surfaces. Repair, patch and touch up marred surfaces to specified finish or to match adjacent surfaces.

1.11 SUBMITTALS

- A. Submittals shall be in accordance with Division 01 of the Project Manual.

B.General

1. The Contractor shall provide to the Professional for review electronic (pdf file format) copies of required submittals, unless noted otherwise. All Catalog Data, Shop Drawings, Calculations, and Certificates of Compliance shall be submitted as a single package. Failure of the contractor to provide a complete submittal package may result in delay in processing time. All such delays to the job resulting from the contractor's failure to provide submittals at one time will be the responsibility of the Contractor. Submittals will be returned to the Architect / Contractor. Submittals shall clearly identify the contract documents specification section or drawing referenced, identifying and highlighting each item to be reviewed.
2. Submittals provided for review shall clearly and completely describe the specific product(s) they represent. Where differences exist between the item specified and that submitted for review, the submittal shall be highlighted.
3. Submittals shall bear the review stamp of the Contractor. The review stamp of the Contractor shall be affixed to shop drawings to indicate:
 - a. The Contractor has coordinated the electrical characteristics of the equipment.
 - b. The Contractor has verified that the equipment submitted will physically fit into the space allocated with adequate clearances for maintenance, access, and egress requirements.
 - c. The Contractor shall bear all associated costs that may accrue due to failure to completely represent a given product.

4. Material and equipment shown on the drawings or specified herein shall not be incorporated in the work of this Contract until shop drawings, engineering data and catalog information have been reviewed and accepted by the Professional.

C. Trade Name References

1. Material and equipment are described and listed in the Project Documents by trade name, by manufacturer's name and model number, or by performance attributes. It is intended that trade names or manufacturer's names shall establish standards of quality, performance, capacity, materials, and design for the item specified.
2. Where more than one manufacturer is listed for an item, those mentioned are considered equivalent if the quality, style, capacities, materials and performance of the specified item are equivalent. All materials and equipment shall be subject to the acceptance by the Professional.

D. Substitutions

1. No substitution shall be made without the review and acceptance by the Professional.
2. Where the phrase "or accepted substitute" or "or equal" appears in the Contract Documents, it shall refer to the requirement of acceptance by the Professional of the material or equipment involved.
3. It shall be the responsibility of the Contractor to ensure that each manufacturer can furnish a substitute in complete conformity with the requirements of this Project. The Contractor shall assume all costs or extra charges associated with the substitution, including: any architectural, structural, mechanical, or electrical changes required, costs in connection with work of the other trades necessitated substitutes, and any additional engineering costs required.
4. The Contractor shall indicate the specified equivalent on shop drawings or catalog data which are submitted as substitutions.
5. At the request of the Professional samples of items that are to be used in substitution of specified items shall be submitted. If such a request is made, a sample of both the specified item and the proposed substitute item shall be submitted simultaneously. The scheduling of the submission of such samples shall be as directed and shall in no way delay the progress of the project. The Professional will assume no liability whatsoever for any samples submitted.

E. Operation and Maintenance Manuals

1. Submit two (2) sets of 8-1/2" x 11" text sixty (60) days prior to operator training/pre-final inspection bound in three D side ring capacity expansion binders with durable plastic covers for review by the Professional.

2. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", title of project, and subject matter of binder when multiple binders are required.
3. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
4. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified type on thirty (30) pound white paper.
 - a. Part 1: Directory, listing names, addresses, and telephone numbers of Professional, Contractor, Subcontractors, and equipment suppliers.
 - b. Part 2: Operation and maintenance instructions arranged by system or process floor and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:
 - 1) Significant design criteria.
 - 2) List of equipment.
 - 3) Parts list for each component.
 - 4) Maintenance instructions for equipment and systems.
 - 5) Maintenance instructions for finishes, including recommended cleaning methods and materials and Operating instructions.
 - 6) Special precautions identifying detrimental agents.
 - 7) Special Requirements of other sections of this specification noted to be included in the operating and maintenance manual.
 - c. Part 3: Project documents and certificates, including the following:
 - 1) All approved Submittals
 - 2) Certificates of Compliance
 - 3) Photocopies of warranties and bonds
 - 4) Material safety data sheets
5. Submit five (5) copies of completed volumes in final form fifteen (15) days prior to owner training. These copies will include Professional's previous review comments.
6. Submit eight final volumes revised, within ten (10) days after pre-final observation.

F. Samples

1. The Contractor shall furnish, for review by the Professional, all samples specified or requested by the Professional. The finished work shall match accepted samples and shop drawings.

1.12 ELECTRICAL EQUIPMENT

- A. The Contractor shall furnish all motors, combination starters/disconnects, overload protection and controls for equipment required to provide complete and workable systems, unless noted otherwise.
- B. All motors, motor control equipment and wiring shall meet the requirements of the National Electric Code and shall comply with the requirements of the Public Utility Company furnishing service and with the rules and regulations of all Authorities Having Jurisdiction.
- C. The contractor shall verify electrical characteristics at the site before ordering electrical equipment.
- D. Motors under $\frac{1}{2}$ (one-half) horsepower shall be 120 volts. Motors $\frac{1}{2}$ (one-half) horsepower and over shall be 3 (three) phases. All motors to be 1750 revolutions per minute (rpm) unless noted otherwise. Combination motor starters shall be of the fused switch type to complete with magnetic motor starter. Units shall be of the NEMA size and type applicable to motor size, with 3-pole overload. Overload elements and fuses shall be of the proper size to protect the motor. Unless noted otherwise, units shall be equipped with indicating lights, HAND-OFF-AUTOMATIC (HOA) selector switch, 4 (four) auxiliary contacts 2 (two) normally open (N.O.) and 2 (two) normally closed (N.C.) and fused control transformer to provide 120-volt control voltage. Fusible disconnect switch operating handles shall be interlocked with the door so that the door cannot be opened with the switch in the "ON" position, except through a hidden release mechanism. The operating handle shall be arranged for padlocking in the "OFF" position with up to three padlocks. Fuses shall be furnished by the Contractor as required to comply with NEC requirements. Where R type fuses are indicated, fuse holders shall be provided with rejection clips. Equipment shall be Square D, Allen-Bradley, or General Electric or accepted substitute, and shall be provided with a NEMA Type 1 enclosure, unless noted otherwise.

1.13 CONTROL WIRING

- A. The Contractor shall provide all necessary control wiring and related conduit required for complete and workable systems.
- B. All conduit and wiring shall be in accordance with the latest edition of the National Electrical Code. Installation of control wiring shall be performed in a neat and workmanlike manner by competent workmen. Workmanship shall be as specified in Division 26.

- C. Control circuits shall be wired for 110-volt control, using fused individual control transformers. Circuits shall be fused and shall be interrupted when the disconnect device is opened.

1.14 EXCAVATION, BACKFILLING AND COMPACTION

- A. Excavation, Backfilling and Compaction shall comply with Division 31 of the Project Manual

B.General

1. The Contractor shall notify one call prior to any work.
2. The Contractor shall perform all excavation, backfilling, compaction and necessary finishing for all piping, equipment, and accessories. Piping installation shall be in accordance with local water, sewer and gas utility regulations and applicable State and Local codes.
3. Protect existing structures, utilities, sidewalks, pavements and other facilities not indicated for removal, from damage caused by settlement, lateral movement, undermining, washout and other hazards resulting from excavation operations.
4. Existing utility lines shown on the Project Documents may not indicate the exact in-place location of the lines. They do not show every pipe, fitting or appurtenance that may exist at the project site. The location and depth of all utilities shall be marked and recorded prior to any excavation. Should uncharted or incorrectly charted, existing piping or other utilities be uncovered during excavation, contact the Professional immediately for directions before proceeding further with work in this area. Cooperate with owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to the satisfaction of the utility owner.
5. If it becomes necessary to install any lines or equipment in locations other than those shown, the Professional's acceptance shall be obtained before starting the excavation.
6. The presence of explosives on the project site or the use of explosives in the execution of the work under this contract is not permitted.

C.Excavation

1. All plumbing excavation is unclassified.
 - a. Paved Areas – When working within the right-of-way limits of all North Carolina State highways, backfilling must be in conformance with the requirements of the North Carolina Department of Transportation, which is made a part of these specifications by this reference thereto.

D. Compaction

1. Comply with Division 31 of the Project Manual.

1.15 CONCRETE

- A. Comply with Division 03 of the Project Manual.
- B. Reinforcing shall conform to ASTM A-615, Grade 60. Concrete exposed to freezing and thawing, salts, sulfates and corrosion shall comply with International Building Code with North Carolina amendments.
- C. All concrete shall be of minimum 3000 pounds per square inch (psi) strength in 28 (twenty-eight) days. All concrete shall be mixed by machine. No wet or moistened mixture containing cement shall remain unplaced for a period exceeding 30 (thirty) minutes and shall not be used after its initial set. Re-tempering after initial set is prohibited. Exposed surfaces shall be protected from drying for at least 7 (seven) days. All forms shall be built true and rigid. Form removal shall not injure the concrete.
- D. All concrete is to be finished with a hard, smooth troweled finish and is to be faced smooth with rounded corners.

1.16 INSPECTION AND TESTING

- A. General
 1. New plumbing systems and parts of existing systems which have been altered, extended or repaired shall be tested to disclose leaks and defects.
 2. The Contractor shall notify the Professional a minimum of 5 (five) working days prior to testing to coordinate the testing and inspection procedures.
 3. If the Professional determines that the plumbing systems do not pass the prescribed tests, then the Contractor shall be required to make the necessary repairs, at his own expense, and the Contractor shall re-inspect and re-test the systems. Repairing, inspection and testing shall be continued until all systems pass as determined by the Professional.
 4. All new, altered, extended or replaced plumbing shall be left uncovered and unconcealed until it has been inspected, tested and accepted by the Professional. Where such work has been covered, or concealed before it has been inspected, tested and accepted, it shall be uncovered by the contractor, at his own expense as directed by the Professional.
 5. All equipment, material, labor, etc., required for testing the plumbing systems shall be furnished by the Contractor.
 6. The Engineer or Engineer's representative is the inspector for the state. The Engineer or Engineer's representative shall witness all pipe installations, pressure tests, etc. Underground piping shall be kept uncovered until all testing has been completed and the installation methods have been approved. If the underground

pipe is covered before approval, it shall be uncovered at the Contractor's expense for inspection and testing.

B. Sanitary Waste and Vent Systems

1. The system shall be tested in accordance with the North Carolina State Plumbing Code.
2. Rough Plumbing – Systems shall be tested upon completion of the rough piping installation and proved watertight. The water test shall be applied to the system either in its entirety or in sections after rough piping has been installed.
 - a. Where applied to the entire system, all openings in the piping shall be closed, except the highest opening, and the system filled with water to point of overflow.
 - b. Where the system is tested in sections, each opening shall be plugged, except the highest opening of the section under test, and each section shall be filled with water. A section shall not be tested with less than a 10-foot head of water.
 - c. In testing successive sections, at least the upper 10-feet of the next preceding section shall be tested, such that a joint or pipe in the building, except the uppermost 10 feet of the system, shall not have been subjected to a test of less than a 10-foot head of water.
 - d. The water shall be kept in the system or in the portion under test for a minimum of 2 (two) hours before inspection starts. The system shall then be inspected to ensure that it is tight at all points.
 - e. The Contractor shall provide a written Test and Inspection Report that the above prescribed test(s) have been performed in accordance with these Specifications. The report is subject to approval by the Professional.
3. Finished Plumbing – After the plumbing fixtures have been set and their traps filled with water, the plumbing fixture connections shall be tested and proved gas and watertight.
 - a. A smoke test shall be made by filling all traps with water and then introducing into the system smoke produced by one or more smoke machines. When the smoke appears at stack openings on the roof, the stack openings shall be closed and a pressure equivalent to a 1-inch water column shall be introduced and maintained for the period of the inspection.
 - b. Where the local Authority Having Jurisdiction finds that a smoke test need not be performed, a peppermint test shall be performed. Two (2) ounces of oil of peppermint shall be poured into the roof terminal of every line or stack to be tested. The oil of peppermint shall be followed at once by 10

quarts of hot (140-degrees Fahrenheit) water. All roof vent terminals shall then be sealed. The system shall then be inspected for the detection of odor of peppermint. If odor of peppermint is detected, repairs shall be made and the system shall be retested.

- c. The above tests shall be witnessed by the Authority Having Jurisdiction or by Professional or his representative.
- d. The Contractor shall provide a written Test and Inspection Report that the above prescribed test(s) have been performed in accordance with these Specifications. The report is subject to approval by the Professional.

C. Building Sewer

- 1. The building sewer shall be tested by insertion of a test plug at the point of connection with the public sewer. The building sewer shall then be filled with water under a head of not less than 10-feet. The water level at the top of the test head of water shall not drop for at least 15 (fifteen) minutes.

D. Domestic Water Systems

- 1. The system shall be tested either in its entirety or in sections.
- 2. The system shall be tested and proved tight under a water pressure of 125 pounds per square inch for a period of 2 hours.
- 3. Potable water shall be used for testing.

1.17 STERILIZATION OF THE DOMESTIC WATER SYSTEM

- A. After the system has been tested and approved, the entire new system, including valves and accessories, shall be chlorinated. Disinfecting shall be in accordance with AWWA C651.

B. Chlorine may be applied in any of the following forms:

- 1. Liquid chlorine gas-water mixture
 - a. Chlorine gas-water mixture shall be applied by a solution feed chlorinating device.
- 2. Direct chlorine gas feed
 - a. Chlorine gas shall be fed directly from a chlorine cylinder with a suitable device for regulating the rate of flow and the effective diffusion of gas within the line.
- 3. Calcium hypochlorite and water mixture.

- a. Calcium hypochlorite shall be HTH, Perchlorene and Maxochlor, or accepted substitute. A solution consisting of five (5%) percent powder to ninety-five (95%) percent water by weight shall be prepared. The calcium hypochlorite and water mixture, first made into a paste and then thinned to a slurry, shall be injected or pumped into the system.
- C. The system or part thereof shall be filled with a water/chlorine solution containing at least 50 parts per million of chlorine, and the system or part thereof shall be valved off and allowed to stand for 24 hours; or the system or part thereof shall be filled with a water/chlorine solution containing at least 200 parts per million of chlorine and allowed to stand for 3 hours. During the chlorination process all valves and accessories shall be operated.
- D. After the chlorination process, the chlorine shall be flushed from the system until the system water is equal in chemical and bacteriological composition to those of the permanent source of water supply.
- E. Laboratory tests of the water shall be paid for by the Contractor.

1.18 INSTRUCTION OF THE OWNER

- A. After acceptance of the Project, the Contractor shall furnish the services of personnel thoroughly familiar with the completed installation to instruct the Owner in the proper operation and maintenance of all equipment and appurtenances provided.
- B. The Contractor shall provide the Owner with two weeks' notice before the instruction session.

1.19 CHASES AND OPENINGS

- A. All chases and openings required for the installation of the work shall be coordinated with the other trades. The Contractor shall provide the other trades with sufficient time (1 (one) week minimum) for coordination of all chases and openings. The contractor shall be responsible for all work required to cut and patch the required openings. The work shall be performed to the satisfaction of the Professional.
- B. Penetrations made in fire rated chases, partitions, floors, etc. shall be sealed with an approved material and method as required to maintain the integrity of the fire separation.
- C. The Contractor shall provide all sleeves, hangers, and anchors required for installation of the work in chases and openings.

1.20 WATER SERVICE AND METERS

- A. The Contractor shall coordinate water meter requirements in accordance with the local water utility regulations, including required permits, meters, piping, valves, by passes, supports and other accessories.

1.21 PAINTING

- A. Painting shall be in accordance with Division 09.

1.22 RELATED WORK

- A. All work related to providing complete plumbing systems and equipment shall be the responsibility of the Contractor. The following related work shall be provided as indicated in other specification Divisions, unless noted otherwise, but shall remain the responsibility of the Contractor for workmanship and completeness:

- 1. General Contractor

- a. Installation of access panels.
 - b. Leaders and gutters.
 - c. New catch basins and foundation drains. Final connections shall be by the Contractor, as indicated on the drawings and as herein specified.
 - d. Final painting of existing walls, floors and ceilings where the surfaces are being refinished and remodeled under the General Contract. Refer to General Construction Drawings.
 - e. Installation and flashing of roof penetrations including but not limited to roof drains, vents through roof, gas piping, etc. Final connections shall be provided by the Contractor.
 - f. Concrete housekeeping pads for plumbing equipment.

- 2. Mechanical Contractor

- a. Condensate drain piping.

- 3. Electrical Contractor

- a. Installation of all combination starters/disconnects and overload protectors.

1.23 MISCELLANEOUS STEEL AND ACCESSORIES

- A. The contractor shall provide all necessary steel angles, channels, pipe, rods, nuts, bolts, etc., as shown on plans, as specified, or as may be required for complete and proper installation of plumbing fixtures, systems and equipment. All material and workmanship shall be of the best quality and shall be installed in accordance with the best practices of the trade.

1.24 ACCESS PANELS

- A. The Contractor shall furnish access doors to the General Contractor for installation in ceilings, walls, partitions and floors for access to valves, traps, fittings, and all appurtenances.
- B. Access panels shall be of sufficient size to permit removal or access to equipment, except that the minimum size shall be 12-inches by 16-inches.
- C. Access door locations shall be as determined by field conditions for optimum access to equipment and shall be reviewed by the Professional before final installation and shall be subject to the following.
 - 1. Bottom of access doors shall not be lower than the top of the partition base, or a minimum of 6 inches above floor.
 - 2. Tops and/or sides of access panels shall be a minimum of 6-inches from the ceiling or opening or from the edge of a wall return.
- D. Access doors shall be suitable for installation in the finish material of the ceilings, walls, partitions and floors.
- E. Frame and panel access doors in restrooms, kitchens and as indicated shall be stainless steel.
- F. Access doors with UL Listing shall be provided in rated construction assemblies. Access doors shall be "B-Label" and shall have a UL one and one-half (1-1/2) hour rating at 250 degrees F rating for both door and frame. Maximum size shall be 20" x 20" or 400 square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), continuous type hinge on one side, flush-face type lock with key operation and self-latching cylinder locks.
- G. Access doors without UL label shall be provided in all non-rated construction assemblies: Frame shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges and flush-face type lock with key operation and self-latching cylinder locks. Door shall open 175 degrees (minimum).
- H. All access doors shall be keyed alike.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials used on plumbing systems shall comply with the following lead ban requirements:
 - 1. Solders with lead content exceeding 0.2% (two-tenths of a percent) are prohibited. Brass and bronze materials containing 8.0% (eight percent) or greater lead are prohibited.

PART 3 - EXECUTION

3.1 GENERAL

- A. All materials and equipment used shall be installed in strict accordance with the Standards under which the materials are accepted and approved, and in strict accordance with the manufacturer's instructions.
- B. The Contract Documents are not intended to indicate every bend, offset, change in direction and appurtenance required to provide a complete and workable system.
- C. The contract drawings are diagrammatic and are indicative of the work to be performed. It is not intended that they show every pipe, fitting or apparatus required for a complete installation.
- D. Except where otherwise indicated, minimum cover shall not be less than the following:
 - 1. sanitary sewer piping: 3'-0"
 - 2. storm sewers: 1'-0"
 - 3. water piping: 3'-0"

3.2 EQUIPMENT INSTALLATION - COMMON 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 plumbing 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.

3.3 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

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.

END OF SECTION 22 0500

SECTION 22 0503 - PLUMBING PIPE, TUBE AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Pipe and pipe fittings for the following systems:
 - 1. Domestic water piping within 5 feet of building.
 - 2. Sanitary waste and vent piping, within 5 feet of building.
 - 3. Equipment drains and overflows.
 - 4. Unions and flanges.
 - 5. Underground pipe markers.
- B. Related Sections:
 - 1. Division 08 - Access Doors and Frames
 - 2. Division 09 - Painting
 - 3. Section 22 05 23 - General-Duty Valves for Plumbing Piping.
 - 4. Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment.
 - 5. Section 22 07 00 - Plumbing Insulation.
 - 6. Division 31 - Excavation, Trenching and Backfill

1.2 REFERENCES

- A. American Society of Mechanical Engineers:
 - 1. ASME Section IX - Boiler and Pressure Vessel Code - Welding and Brazing Qualifications.
- B. ASTM International:
 - 1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 2. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
 - 3. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes.
 - 4. ASTM B75 - Standard Specification for Seamless Copper Tube.
 - 5. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

6. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV).
 7. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 8. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 9. ASTM D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- C. American Welding Society:
1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
 2. AWS D1.1 - Structural Welding Code - Steel.
- D. American Water Works Association:
1. AWWA C104 - American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 2. AWWA C151 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
- E. Cast Iron Soil Pipe Institute:
1. CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
 2. CISPI 310 – Standard Specification for Couplings for use with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
 3. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe institute (CISPI) and be listed by NSF International.

1.3 SUBMITTALS

- A. Division 01 - Submittal Procedures.
- B. Shop Drawings: Indicate layout of piping systems, including equipment, critical dimensions, and sizes.
- C. Product Data: Submit data on pipe materials and fittings. Submit manufacturers catalog information.
- D. Welders' Certificate: Include welders' certification of compliance with ASME Section IX.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with ASME B31.9 code for installation of piping systems and ASME Section IX for welding materials and procedures.
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.
- C. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum five years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum 10 years documented experience.
- C. Design pipe hangers and supports under direct supervision of Professional Engineer experienced in design of this Work and licensed at Project location

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Requirements for transporting, handling, storing, and protecting products.
- B. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Environmental conditions affecting products on site.
- B. Do not install underground piping when bedding is wet or frozen.

1.8 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.9 COORDINATION

- A. Division 01 - Requirements for coordination.
- B. Coordinate installation of buried piping with trenching.

PART 2 PRODUCTS

2.1 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

Pipe 3 inch and larger:

- A. Ductile Iron Pipe: AWWA C151.
 - 1. Fittings: AWWA C110, ductile or gray iron, standard thickness.
 - 2. Joints: AWWA C111, rubber gasket with rods.

Pipe 2½ inch and smaller:

- B. Copper Tubing: ASTM B88, Type K hard drawn or annealed.
 - 1. Fittings: ASME B16.18, cast copper, or ASME B16.22, wrought copper.
 - 2. Joints:
 - a. 2" and smaller: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
 - b. 2-1/2" and larger: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.2 DOMESTIC WATER PIPING, ABOVE GRADE (MECHANICAL ROOM ONLY)

- A. Copper Tubing: ASTM B88, Type L hard drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints:
 - a. 2" and smaller: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
 - b. 2-1/2" and larger: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.3 DOMESTIC WATER PIPING, ABOVE GRADE (THROUGHOUT FACILITY EXCEPT AS NOTED OTHERWISE)

- A. Size 2" and smaller: Crosslinked Polyethylene (PEX-Type a) piping (ASTM F876 and F877) and cold expansion fittings (ASTM F1960).
 - 1. PEX-a Fittings: elbows, adapters, couplings, plugs, tees and multi-port tees (1/2 inch through 3-inch nominal pipe size): ASTM F19960 cold-expansion fitting manufactured from the following material types:

- a. UNS No. C69300 Lead-free (LF) Brass.
 - b. UNS No. C27453 Lead-free (LF) Brass.
 - c. Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked "F1960".
 - 2. Provide PEX-a pipe supports in order to route piping in a neat workman like appearance, parallel and perpendicular to structure.
 - a. Pipe supports: 23-gauge, galvanized steel with support straps.
 - 3. Insulate PEX piping per Section 220700.
 - B. Size 2-1/2" and larger: Copper Tubing: ASTM B88, Type L hard drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints:
 - a. 2-1/2" and larger: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.
- 2.4 SANITARY WASTE PIPING, BURIED WITHIN 5 FEET OF BUILDING
- A. PVC Pipe: ASTM D2665, Schedule 40, solid wall, polyvinyl chloride (PVC) material, bell and spigot style solvent sealed joint ends.
 - 1. Fittings: ASTM D2466, Schedule 40, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 Solvent cement.
- 2.5 SANITARY WASTE AND VENT PIPING, ABOVE GRADE
- A. PVC Pipe: ASTM D2665, Schedule 40, solid wall, polyvinyl chloride (PVC) material, bell and spigot style solvent sealed joint ends.
 - 1. Fittings: ASTM D2466, Schedule 40, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 Solvent cement.
 - B. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.23, cast bronze, or ASME B16.29, wrought copper.
 - 2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
- 2.6 EQUIPMENT DRAINS AND OVERFLOWS
- A. Copper Tubing: ASTM B88, Type DWV.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.

2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
3. Fittings: ASME B16.18 cast copper alloy, or ASME B16.22 wrought copper and bronze, or ASTM B584 bronze sand castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).

2.7 UNIONS AND FLANGES

- A. Unions for Pipe 2 inches and Smaller:
 1. Ferrous Piping: Class 150, malleable iron, threaded.
 2. Copper Piping: Class 150, bronze unions with soldered joints.
 3. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
- B. Flanges for Pipe 2-1/2 inches and Larger:
 1. Ferrous Piping: Class 150, forged steel, slip-on flanges.
 2. Copper Piping: Class 150, slip-on bronze flanges.
 3. Gaskets: 1/16-inch-thick preformed neoprene gaskets.
- C. Flange Adapter for Pipe 2 inches and Larger:
 1. Ferrous Piping: Class 125, 150 & 300, ductile iron, flat faced. Victaulic Style 741, 743 & W741.
 2. Copper Piping: 300 psi, ductile iron coated with copper-colored enamel, flat faced. Victaulic Style 641.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01 - Verification of existing conditions before starting work.
- B. Verify excavations are to required grade, dry, and not over-excavated.
- C. Verify trenches are ready to receive piping.

3.2 PREPARATION

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

- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.3 INSTALLATION - BURIED PIPING SYSTEMS

- A. Verify connection to site piping system size, location, and invert are as indicated on Drawings.
- B. Establish elevations of buried piping with not less than 2 ft of cover.
- C. Establish minimum separation from other services in accordance with applicable codes.
- D. Install plastic pipe as required per ASTM D2321.
- E. Install pipe to elevation as indicated on Drawings.
- F. Install pipe on prepared bedding.
- G. Route pipe in straight line.
- H. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- I. Install plastic ribbon tape continuous, buried 12 inches below finish grade and above pipeline; coordinate with Division 31. Refer to Section 22 05 00.
- J. Pipe Cover and Backfilling:
 - 1. Backfill trench in accordance with Section 22 05 00.

3.4 INSTALLATION - ABOVE GROUND PIPING

- A. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- B. Install piping to maintain headroom without interfering with use of space or taking more space than necessary.
- C. Group piping whenever practical at common elevations.
- D. Sleeve pipe passing through partitions, walls and floors. Refer to Section 22 05 29.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 07 00.
- G. Provide access where valves and fittings are not accessible. Coordinate size and location of access doors with Division 08.

- H. Install non-conducting dielectric connections wherever jointing dissimilar metals.
- I. Establish invert elevations, slopes for drainage to 1/8 inch per foot minimum (1/4 inch per foot for 2" pipes). Maintain gradients.
- J. Slope piping and arrange systems to drain at low points.
- K. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.
- L. Install piping penetrating roofed areas to maintain integrity of roof assembly.
- M. Install valves in accordance with Section 22 05 23.
- N. Insulate piping. Refer to Section 22 07 00.
- O. Install pipe identification in accordance with Section 22 05 53.

3.5 INSTALLATION - DOMESTIC WATER PIPING SYSTEMS

- A. Install domestic water piping system in accordance with ASME B31.9.
- B. Pipes carrying pressurized water and laid under the building shall be installed with NO joints.
- C. Press-Connect Joints for Copper Tubing: Join copper tube and pressure-connect fittings with tools recommended by fitting manufacturer.
 - 1. Mark proper insertion depth prior to making press connections.

3.6 INSTALLATION - SANITARY WASTE AND VENT PIPING SYSTEMS

- A. Install sanitary waste and vent piping systems in accordance with ASME B31.9.
- B. Install sanitary waste and vent piping systems in accordance with local plumbing code.
- C. Install bell and spigot pipe with bell end upstream.

3.7 FIELD QUALITY CONTROL

- A. Refer to Division 01 - Execution and Closeout Requirements: Field inspecting, testing and adjusting.
- B. Test domestic water piping system in accordance with applicable code. Refer to Section 22 05 00.
- C. Test sanitary waste and vent piping system in accordance with applicable code. Refer to Section 22 05 00.

3.8 CLEANING

- A. Division 01 – Execution and Closeout Requirements: Field inspecting, testing and adjusting.

- B. Clean and disinfect domestic water distribution system in accordance with Section 22 05 00.

END OF SECTION 22 0503

SECTION 22 0515 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cleanouts
2. Floor Drains and Floor Sinks
3. Hose Bibbs
4. Wall Hydrants
5. Trap Primers
6. Backflow Preventers
7. Water Hammer Arrestors
8. Thermometers
9. Pressure Gauges
10. Balancing Valves
11. Thermostatic Mixing Valves
12. Water Meters

B. Related Sections:

1. Division 08 - Access Doors and Frames
2. Division 09 – Painting
3. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
4. Section 22 05 23 - General-Duty Valves for Plumbing Piping.
5. Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment.
6. Section 22 07 00 - Plumbing Insulation.
7. Division 31 - Excavation, Trenching and Backfill

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.3 SUBMITTALS

- A. Division 01 - Submittal Procedures.
- B. Product Data: Submit data on pipe materials and fittings. Submit manufacturers catalog information.

1.4 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum five years documented experience.
- B. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- C. All domestic water specialties shall be Lead-Free compliant products designed and manufactured to comply with ANSI / NSF 372 and NSF 61, Annex G.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Requirements for transporting, handling, storing, and protecting products.
- B. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Storage of Specialties on site – Specialties not be exposed to the elements and shall not be stored directly on ground.

1.6 DEFINITIONS

- A. HDPE: High-density polyethylene plastic
- B. PE: Polyethylene plastic
- C. PP: Polypropylene plastic

PART 2 - PRODUCTS

2.1 CLEANOUTS

- A. Floor Cleanouts
 - 1. Approved manufacturers: Zurn, JR Smith, Wade
 - 2. Coated cast-iron body, gas and watertight ABS tapered thread plug, and round scoriated secured nickel bronze top adjustable to finished floor.
 - 3. Carpeted Areas: Provide cleanout with carpet marker.
 - 4. Tile Floor Areas: Provide cleanout with square top recessed for 1/8" tile.

5. Terrazzo Floor Areas: Provide cleanout with round top recessed for 1-1/4" terrazzo.
6. Standard: ASME A112.36.2M
7. Size: Same as connected branch up to 4". Use 4" cleanouts for connected branch sizes larger than 4".

B. Wall Cleanouts

1. Approved manufacturers: Zurn, JR Smith, Wade
2. Standard: ASME A112.36.2M
3. Size: Same as connected drainage piping up to 4".
4. Round stainless-steel wall access cover with securing screw and bronze raised head plug.

C. Exposed Piping Cleanouts

1. Approved manufacturers: Zurn, JR Smith, Wade
2. Countersunk, bronze cleanout plug.

2.2 FLOOR DRAINS AND FLOOR SINKS

- A. Approved manufacturers: Zurn, JR Smith, Wade
- B. Coated cast-iron body unless otherwise indicated.
- C. Provide floor drain and floor sink with deep seal p-trap.
- D. Kitchen Areas – Provide stainless steel floor drains and floor sinks as specified on drawings.

2.3 HOSE BIBBS

- A. Approved manufacturers: Woodford, Zurn, JR Smith
- B. See Drawing for specification of hose bibbs.

2.4 WALL HYDRANT

- A. Approved manufacturers: Woodford, Zurn, JR Smith
- B. See Drawing for specification of wall hydrants.

2.5 TRAP PRIMERS

- A. Approved manufacturers: Precision Plumbing Products (PPP), Sioux Chief, MIFAB

B. Hydraulic Type

1. $\frac{1}{2}$ " inlet / $\frac{1}{2}$ " outlet fully automatic, all brass type primer valve, activated by a drop-in building water pressure, no adjustment required. Model for one to four traps with distribution unit, may be located anywhere in an active cold-water line, as indicated on the drawings or as required by code. ASSE Standard 1018. Omit distribution unit when serving a single trap.

- C. Provide Trap Guards where allowed by Authority Having Jurisdiction. Waterless inline Trap Guard conforming to ASSE 1072 equal to Recotorseal "Sure Seal" Model SS3009V. Install Trap Guards in the outlet of the floor drain, not in the strainer. Add hose bibb in room in order to provide a means to wet the p-trap.

2.6 BACKFLOW PREVENTORS

- A. Approved manufacturers: Ames, Watts, Wilkins, Apollo
- B. Backflow preventors shall be installed where shown on the drawings and conform to the type required by the local water authority.
- C. Units shall be supported in accordance with manufacturer's recommendations.
- D. Reduced Pressure Backflow Preventors – The assembly shall consist of an internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs. Seats and seat discs shall be replaceable in both check modules and the relief valve. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. Body and shutoffs shall be constructed using Lead Free cast copper silicon alloy materials. Lead Free reduced pressure zone assembly shall comply with state codes and standards, where applicable, requiring reduced lead content. The assembly shall also include two resilient seated isolation valves, four resilient seated test cocks and an air gap drain fitting. The assembly shall meet the requirements of ASSE 1013.

2.7 WATER HAMMER ARRESTERS

- A. Approved manufacturers: Precision Plumbing Products (PPP), Sioux Chief, Zurn
- B. Water hammer arresters shall have sufficient volume of air to dissipate the calculated kinetic energy generated in the piping system. Arresters shall be effective when installed at any angle. Water hammer arresters shall be ANSI/ASSE 1010 2004 certified. Arresters shall be sized and placed per manufacturer's instructions.

2.8 THERMOMETERS

- A. Approved manufacturers: Ernst Gage, Weiss Instruments, Weksler
- B. 4-inch mercury type. Temperature range shall be 0°F to 200°F.

2.9 PRESSURE GAGES

- A. Approved manufacturers: Ernst Gage, Weiss Instruments, Weksler
- B. 4-1/2-inch dial, stainless steel and phosphor bronze movement, gauge cock and throttling device. Pressure range shall be 0 psi to 150 psi.
 - 1. Operating point of gauge shall be on middle third of pressure range.

2.10 BALANCING VALVES

- A. Approved Manufacturers: Bell & Gossett, Watts, TACO, Circuit Solver
- B. Valves shall be designed to allow installing contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with pre-set balance schedule.
- C. Valves shall consist of Lead-Free Brass / stainless steel ball construction with glass and carbon filled TFE seat rings. Valves shall have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT inserts/check valves. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves shall have calibrated nameplates to assure specific valve settings. Valves shall be designed for positive shut-off. Valves shall be ANSI/NSF-61, Annex G compliant.

2.11 THERMOSTATIC MIXING VALVES

- A. Approved Manufacturers: Leonard, Symmons, Lawler
- B. High-low Master Mixing Valve – Provide factory assembled and tested large thermostatic water mixing valve, small thermostatic mixing valve, solid bi-metal thermostat (directly linked to valve porting to control the intake of hot and cold water and compensate for supply temperature or pressure fluctuations) with Ten Year Warranty, color coded dials (HOT-COLD with directional indicators), locking temperature regulator handles, adjustable limit stops set for 120 F, intergal hot and cold supply checkstops, outlet ball valve shut-offs and color coded dial thermometer, inlet piping manifold, factory preassembled and tested, rough bronze finish. System shall provide full time standby service should one mixing valve require maintenance and shall be piped according to manufacturer's required piping method. System shall be factory assembled and tested.

2.12 WATER METER

- A. Water meters are to be located inside the mechanical room.
- B. Water meter shall be tied into the Building Management System (BMS). Coordinate with the Controls Contractor.

- C. Water meter and associated register shall be equal to appropriate Neptune Meter with Neptune E-Coder register with the potted cable. R900i register is not compatible since it does not feature a connection wire.
- D. Controls Gateway: Meters not having direct Modbus communication shall be integrated to the BMS through a Modbus gateway equal to Scadаметrics Ethermeter. The gateway device shall directly interrogate the meter register and shall calculate and relay the following parameters to the BMS:
 - 1. Totalized Volume
 - 2. Instantaneous Flowrate
- E. Building Water Meters
 - 1. Mechanical Water Meters 1-1/2 inches and below shall be positive displacement type.
 - 2. Mechanical Water Meters above 2 inches shall be compound type water meter with matching strainer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to 4 inch. Use 4 inch for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 100 feet.
 - 4. Locate cleanouts at the base of each vertical storm drain and 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 backflow preventers in each water supply to buildings and to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with the authorities having jurisdiction.
 - 1. Install drain for backflow preventers with atmospheric-vent drain connection with airgap fitting, fixed airgap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to exterior of the building. Smaller make-up water backflow preventer drains may be routed to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air brakes are unacceptable for this application.
 - 2. Do not install bypass piping around backflow preventers.

- E. Install balancing valves in locations where they can easily be adjusted.
- F. Install water-hammer arrestors in water piping according to PDI-WH 201.
- G. Install air vents at high points of water piping.
- H. Install supply-type, trap seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.2 ADJUSTING

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

3.3 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.
- C. Protect materials stored on site from weather and theft. Do not store materials directly on ground.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test each pressure vacuum breaker and reduced pressure backflow preventer according to authorities having jurisdiction and the device's referenced 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 22 0515

SECTION 22 0523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ball valves.
 - 2. Check valves.
- B. Related Sections:
 - 1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
 - 2. Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment.
 - 3. Section 22 07 00 - Plumbing Insulation

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 - 2. ASTM D4101 - Standard Specification for Propylene Injection and Extrusion Materials.
- B. Manufacturers Standardization Society of the Valve and Fittings Industry:
 - 1. MSS SP 70 - Cast Iron Gate Valves, Flanged and Threaded Ends.
 - 2. MSS SP 71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.
 - 3. MSS SP 78 - Cast Iron Plug Valves, Flanged and Threaded Ends.
 - 4. MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.
 - 5. MSS SP 110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.3 SUBMITTALS

- A. Division 01 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturers catalog information with valve data and ratings for each service.
- C. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures.

- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable style or series number.

1.4 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of valves.
- C. Operation and Maintenance Data: Submit installation instructions, spare parts lists, exploded assembly views.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum years documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not install valves underground when bedding is wet or frozen.

1.8 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Requirements for warranties.
- B. Furnish five-year manufacturer warranty for valves excluding packing.

1.9 EXTRA MATERIALS

- A. Division 01 - Execution and Closeout Requirements: Requirements for extra materials.
- B. Furnish two packing kits for each size valve.

PART 2 PRODUCTS

2.1 BALL VALVES

A. Manufacturers:

1. Apollo Valves, Conbraco Company.
2. Crane Valve, North America.
3. Hammond Valve Model.
4. Jomar Valve
5. Milwaukee Valve Company.
6. NIBCO, Inc. Model.
7. Stockham Valves & Fittings Model.
8. Victaulic

- B. 4 inch and Smaller: MSS SP 110, 600 psi WOG, two-piece brass or bronze body, chrome plated brass ball and stem, full port, PTFE seats, blow-out proof stem, solder or threaded ends, lever handle.

2.2 CHECK VALVES

A. Horizontal Swing Check Valves:

1. Manufacturers:

- a. Apollo Valve, Conbraco Company.
- b. Crane Valve, North America
- c. Hammond Valve.
- d. Jomar Valve
- e. Milwaukee Valve Company.
- f. NIBCO, Inc.
- g. Stockham Valves & Fittings.
- h. Victaulic Company.

2. 2 inches and Smaller: MSS SP 80, Class 150, bronze body and cap, bronze seat, Buna-N or PTFE disc, solder or threaded ends.

3. 2-1/2 inches and Larger: MSS SP 71, Class 125, cast iron body, bolted cap, bronze or cast-iron disc, renewable disc seal and seat, flanged ends.
 4. 2 inches through 4 inches: 300 psi, cast ductile iron body, bonnet cap drilled and tapped with 1/2" NPT, stainless steel Type 316 clapper and clapper pin, grooved ends, Teflon, EPDM or fluoro-elastomer seat and EPDM, fluoro-elastomer bonnet gasket.
- B. Spring Loaded Check Valves:
1. Manufacturers:
 - a. Apollo Valve, Conbraco Company
 - b. Crane Valve, North America.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO, Inc.
 - f. Stockham Valves & Fittings.
 - g. Victaulic Company.
 2. 2 inches and Smaller: MSS SP 80, Class 250 bronze body, in-line spring lift check, silent closing, Buna-N disc, integral seat, solder or threaded ends.
 3. 2-1/2 inches and Larger: MSS SP 71, Class 125, wafer or globe style, cast iron body, bronze seat, center guided bronze disc, stainless steel spring and screws, flanged ends.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify piping system is ready for valve installation.

3.2 INSTALLATION

- A. Install valves with stems upright or horizontal, not inverted.
- B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- C. Install 3/4-inch ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.

- D. Install valves with clearance for installation of insulation and allowing access.
- E. Provide access where valves and fittings are not accessible. Coordinate size and location of access doors with Division 08.
- F. Refer to Section 22 05 29 for pipe hangers.
- G. Refer to Section 22 07 00 for insulation requirements for valves.
- H. Refer to Section 22 05 03 for piping materials applying to various system types.

3.3 VALVE APPLICATIONS

- A. Valves installed in the domestic water piping system shall be Lead-Free per NSF 61, Annex G or NSF 372 requirements.
- B. Install shutoff and drain valves at locations indicated on Drawings in accordance with this Section.
- C. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- D. Install globe valves for throttling, bypass, or manual flow control services.
- E. Install spring loaded check valves on discharge of water pumps including hot water recirculation pumps.
- F. Install ball valves in domestic water systems for shut-off service.
- G. Install globe valves in domestic water systems for throttling service.

END OF SECTION 22 0523

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Inserts.
4. Flashing.
5. Sleeves.
6. Mechanical sleeve seals.
7. Formed steel channel.
8. Firestopping relating to plumbing work.
9. Firestopping accessories.
10. Equipment bases and supports.

B. Related Sections:

1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings.
2. Division 03 - Concrete Forming and Accessories.
3. Division 03 - Cast-In-Place Concrete.
4. Division 07 - Joint Protection.
5. Division 09 - Painting and Coating.
6. Division 07 - Requirements for roof flashing installation.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B31.9 - Building Services Piping.

B. ASTM International:

1. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.

2. ASTM E119 - Method for Fire Tests of Building Construction and Materials.
 3. ASTM E814 - Test Method of Fire Tests of Through Penetration Firestops.
 4. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
 5. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.
- C. American Welding Society:
1. AWS D1.1 - Structural Welding Code - Steel.
- D. FM Global:
1. FM - Approval Guide, A Guide to Equipment, Materials & Services Approved by Factory Mutual Research for Property Conservation.
- E. Manufacturers Standardization Society of the Valve and Fittings Industry:
1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
 2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
 3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- F. Underwriters Laboratories Inc.:
1. UL 263 - Fire Tests of Building Construction and Materials.
 2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
 3. UL 1479 - Fire Tests of Through-Penetration Firestops.
 4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.
 5. UL - Fire Resistance Directory.

1.3 DEFINITIONS

- A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.4 SYSTEM DESCRIPTION

- A. Firestopping Materials: shall comply with ASTM E119, ASTM E814, and/or UL 263, UL 1479 to achieve fire ratings as noted on Drawings for adjacent construction, but not less than 1-hour fire rating.
1. Ratings may be 3-hours for firestopping in through-penetrations of 4-hour fire rated assemblies unless otherwise required by applicable codes.

1.5 PERFORMANCE REQUIREMENTS

- A. Firestopping: Conform to UL for fire resistance ratings and surface burning characteristics.
- B. Firestopping: Provide certificate of compliance from authority having jurisdiction indicating approval of materials used.

1.6 SUBMITTALS

- A. Division 01 - Submittal Procedures.
- B. Product Data:
 - 1. Hangers and Supports: Submit manufacturers catalog data including load capacity.
 - 2. Firestopping: Submit data on product characteristics, performance and limitation criteria.
- C. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.
- D. Manufacturer's Installation Instructions:
 - 1. Hangers and Supports: Submit special procedures and assembly of components.
 - 2. Firestopping: Submit preparation and installation instructions.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.7 QUALITY ASSURANCE

- A. Through Penetration Firestopping of Fire Rated Assemblies: UL 1479 or ASTM E814 with 0.10-inch water gage minimum positive pressure differential to achieve fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
 - 1. Wall Penetrations: Fire F-Ratings as indicated on Drawings, but not less than 1-hour.
 - 2. Floor and Roof Penetrations: Fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
 - a. Floor Penetrations within Wall Cavities: T-Rating is not required.
- B. Through Penetration Firestopping of Non-Fire Rated Floor and Roof Assemblies: Materials to resist free passage of flame and products of combustion.
 - 1. Noncombustible Penetrating Items: Noncombustible materials for penetrating items connecting maximum of three stories.

- 2. Penetrating Items: Materials approved by authorities having jurisdiction for penetrating items connecting maximum of two stories.
- C. Fire Resistant Joints in Fire Rated Floor, Roof, and Wall Assemblies: ASTM E1966 or UL 2079 to achieve fire resistant rating as indicated on Drawings for assembly in which joint is installed.
- D. Fire Resistant Joints Between Floor Slabs and Exterior Walls: ASTM E119 with 0.10-inch water gage minimum positive pressure differential to achieve fire resistant rating as indicated on Drawings for floor assembly.
- E. Surface Burning Characteristics: 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.
- F. Perform Work in accordance AWS D1.1 for welding hanger and support attachments to building structure.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with 5 years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum 5 years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification.
- C. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not apply firestopping materials when temperature of substrate material and ambient air is below 60 degrees F.
- C. Maintain this minimum temperature before, during, and for minimum 3 days after installation of firestopping materials.
- D. Provide ventilation in areas to receive solvent cured materials.

1.11 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.12 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. Furnish five-year manufacturer warranty for pipe hangers and supports.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- A. Manufacturers:
 - 1. Carpenter & Paterson Inc.
 - 2. Creative Systems Inc.
 - 3. Flex-Weld, Inc.
 - 4. Glope Pipe Hanger Products Inc.
 - 5. Michigan Hanger Co.
 - 6. Superior Valve Co.
- B. Plumbing Piping - DWV:
 - 1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
 - 2. Hangers for Pipe Sizes 1-1/2 inches and Larger: Carbon steel, adjustable, clevis.
 - 3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - 4. Vertical Support: Steel riser clamp.
 - 5. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - 6. Copper Pipe Support: Copper-plated, carbon-steel adjustable, ring.
- C. Plumbing Piping - Water:
 - 1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
 - 2. Hangers for Pipe Sizes 1/2 to 4 inches: Carbon steel, adjustable, clevis.

3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches and Larger: Steel channels with welded spacers and hanger rods, cast iron roll.
5. Vertical Support: Copper-plated, Steel riser clamp.
6. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
7. Floor Support for Hot Pipe Sizes 4 inches and Smaller: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
8. Copper Pipe Support: Copper-plated, Carbon-steel ring.

2.2 ACCESSORIES

- A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.3 INSERTS

- A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

- A. Metal Flashing: 26 gage thick galvanized steel.
- B. Metal Counterflashing: 22 gage thick galvanized steel.
- C. Lead Flashing:
 1. Waterproofing: 5 lb./sq. ft sheet lead.
 2. Soundproofing: 1 lb./sq. ft sheet lead.
- D. Flexible Flashing: 47 mils thick sheet butyl; compatible with roofing.
- E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 SLEEVES

- A. Sleeves for Pipes Through Non-Fire Rated Floors: 18 gage thick galvanized steel.
- B. Sleeves for Pipes Through Non-Fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage thick galvanized steel.
- C. Sealant: Acrylic; refer to Section 07 90 00.

2.6 MECHANICAL SLEEVE SEALS

A. Manufacturers:

1. Thunderline Link-Seal, Inc.
2. NMP Corporation.
3. Garlock

B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.7 FORMED STEEL CHANNEL

A. Manufacturers:

1. B-Line Systems.
2. Unistrut Corp.
3. Carpenter & Patterson

B. Product Description: Galvanized 12 gage thick steel. With holes 1-1/2 inches on center.

2.8 FIRESTOPPING

A. Manufacturers:

1. Dow Corning Corp.
2. Fire Trak Corp.
3. Hilti Corp.
4. International Protective Coating Corp.
5. 3M fire Protection Products.
6. Specified Technology, Inc.

B. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.

1. Silicone Firestopping Elastomeric Firestopping: [Single] [Multiple] component silicone elastomeric compound and compatible silicone sealant.
2. Foam Firestopping Compounds: [Single] [Multiple] component foam compound.

3. Formulated Firestopping Compound of Incombustible Fibers: Formulated compound mixed with incombustible non-asbestos fibers.
 4. Fiber Stuffing and Sealant Firestopping: Composite of [mineral] [ceramic] fiber stuffing insulation with silicone elastomer for smoke stopping.
 5. Mechanical Firestopping Device with Fillers: Mechanical device with incombustible fillers and silicone elastomer, covered with sheet stainless steel jacket, joined with collars, penetration sealed with flanged stops.
 6. Intumescent Firestopping: Intumescent putty compound which expands on exposure to surface heat gain.
 7. Firestop Pillows: Formed mineral fiber pillows.
- C. Color: As selected from manufacturer's full range of colors.

2.9 FIRESTOPPING ACCESSORIES

- A. Primer: Type recommended by firestopping manufacturer for specific substrate surfaces and suitable for required fire ratings.
- B. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.
- C. General:
1. Furnish UL listed products or products tested by other approved independent testing laboratory.
 2. Select products with rating not less than rating of wall or floor being penetrated.
- D. Non-Rated Surfaces:
1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where piping is exposed.
 2. For exterior wall openings below grade, furnish mechanical sealing device to continuously fill annular space between piping and cored opening or water-stop type wall sleeve.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify openings are ready to receive sleeves.
- C. Verify openings are ready to receive firestopping.

3.2 PREPARATION

- A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.
- B. Remove incompatible materials affecting bond.
- C. Install backing or damming materials to arrest liquid material leakage.
- D. Obtain permission from Architect/Engineer before using powder-actuated anchors.
- E. Obtain permission from Architect/Engineer before drilling or cutting structural members.

3.3 INSTALLATION - INSERTS

- A. Install inserts for placement in concrete forms.
- B. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

3.4 INSTALLATION - PIPE HANGERS AND SUPPORTS

- A. Install in accordance with ASME B31.1, ASME B31.5, ASME 31.9, ASTM F708, MSS SP 58, MSS SP 69, MSS SP 89.
- B. Where insulated horizontal piping occurs, provide hanger of adequate size to allow for pipe insulation to be run continuously through the hanger assembly.
- C. Support vertical piping and tubing at base and at each floor.
- D. Support horizontal piping as scheduled.
- E. Install hangers with minimum 1/2-inch space between finished covering and adjacent work.
- F. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- G. Maximum spans below were taken from MSS SP-69 for water service and from model plumbing codes. Most restrictive piping and spacing dimensions are shown.
- H. Install hangers for CAST-IRON SOIL piping with the following maximum horizontal spacing and minimum rod diameters:

PIPE SIZE	HORIZONTAL HANGER	ROD DIAMETER

(IN.)	SPACING (FT)	(IN.)
1½, 2	5	3/8
3	5	1/2
4, 5	5	5/8
6	5	3/4
8 - 12	5	7/8

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

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

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1¼	7	3/8
1½	9	3/8
2	10	3/8
3	11	1/2
4	12	5/8
6	12	3/4
8 - 12	12	7/8

1. Install supports for vertical steel piping every 15 feet.

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

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1¼	5	3/8
1½, 2	6	3/8

2½	8	1/2
3, 4, 5	10	1/2
6	10	5/8
8	10	3/4

1. Install supports for vertical copper tubing every 10 feet (3 m).
- K. Install hangers for PEX-a tubing per the manufacturer's requirements.
- L. Place hangers within 12 inches of each horizontal elbow.
- M. Use hangers with 1-1/2-inch minimum vertical adjustment.
- N. Support horizontal cast iron pipe adjacent to each hub.
- O. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- P. Support piping and tubing not listed above per MSS SP-69 and manufacturer's written instructions.
- Q. Prime coat exposed steel hangers and supports. Refer to Division 09. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- R. Provide clearance in hangers and from structure and other equipment for installation of insulation. Refer to Section 22 07 00.

3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

- A. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Refer to Section 03 30 00.
- B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.

3.6 INSTALLATION - FLASHING

- A. Provide flexible flashing and metal counterflashing where piping penetrates weather or waterproofed walls and floors.
- B. Flashing for roof penetrations shall be provided by the roofing contractor.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36-inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor, shower and/or mop sink drains watertight to adjacent materials.

- E. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 INSTALLATION - SLEEVES

- A. Exterior watertight entries: Seal with mechanical sleeve seals.
- B. Set sleeves in position in forms. Provide reinforcing around sleeves.
- C. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- D. Extend sleeves through floors 1inch above finished floor level. Caulk sleeves.
- E. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent work with firestopping insulation and caulk [airtight]. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- F. Install chrome plated steel or stainless-steel escutcheons at finished surfaces.

3.8 INSTALLATION - FIRESTOPPING

- A. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping and other items, requiring firestopping.
- B. Fire Rated Surface:
 - 1. Seal opening at rated floor, wall, partition, ceiling, and/or roof as follows:
 - a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
 - b. Size sleeve allowing minimum of 1-inch void between sleeve and building element.
 - c. Pack void with backing material.
 - d. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.
- C. Non-Rated Surfaces:
 - 1. Seal opening through non-fire rated wall, partition, floor, ceiling, and/or roof opening as follows:
 - a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
 - b. Size sleeve allowing minimum of 1 inch void between sleeve and building element.

- c. Install type of firestopping material recommended by manufacturer.
- 2. Install wall escutcheons, floor plates or ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling.
- 3. Exterior wall openings below grade: Assemble rubber links of mechanical sealing device to size of piping and tighten in place, in accordance with manufacturer's instructions.
- 4. Interior partitions: Seal pipe penetrations at clean rooms, laboratories, hospital spaces, computer rooms, telecommunication rooms, data rooms and. Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

3.9 FIELD QUALITY CONTROL

- A. Division 01 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.10 CLEANING

- A. Division 01 - Execution and Closeout Requirements: Requirements for cleaning.
- B. Clean adjacent surfaces of firestopping materials.

3.11 PROTECTION OF FINISHED WORK

- A. Division 01 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect adjacent surfaces from damage by material installation.

END OF SECTION 22 0529

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Nameplates.
 - 2. Tags.
 - 3. Stencils.
 - 4. Pipe markers.
 - 5. Ceiling tacks.
 - 6. Labels.
- B. Related Sections:
 - 1. Division 09 - Painting and Coating: Execution requirements for painting specified by this section.

1.2 REFERENCES

- A. American Society of Mechanical Engineers:
 - 1. ASME A13.1 - Scheme for the Identification of Piping Systems.
- B. University of North Carolina at Wilmington – Design and Construction Guidelines
 - 1. The following is the color standard for Mechanical piping identification:
 - a. Potable Hot and Cold Water and Domestic Hot Water Recirculation – Green
 - b. Non-Potable / Make-up Water / Grey Water – Purple (must be color coded everywhere in the project)
 - c. Fire Protection – Red

1.3 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Product Data: Submit manufacturers catalog literature for each product required.
- C. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of tagged valves; include valve tag numbers.

1.5 QUALITY ASSURANCE

- A. Conform to ASME A13.1 for color scheme for identification of piping systems and accessories.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.

1.7 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.8 EXTRA MATERIALS

- A. Division 01 - Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish two containers of spray-on adhesive.

PART 2 PRODUCTS

2.1 NAMEPLATES

- A. Manufacturers:
 - 1. Craftmark Identification Systems.
 - 2. Safety Sign Co.
 - 3. Seton Identification Products.
- B. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.2 TAGS

- A. Manufacturers:
 - 1. Craftmark Identification Systems.

2. Safety Sign Co.
3. Seton Identification Products.
- B. Metal Tags:
 1. Aluminum with stamped letters; tag size minimum 1½ inches diameter with finished edge.
- C. Information Tags:
 1. Clear plastic with printed "Danger," "Caution," or "Warning" and message; size 3-1/4 x 5-5/8 inches with grommet and self-locking nylon ties.
- D. Tag Chart: Typewritten letter size list of applied tags and location in anodized aluminum frame.

2.3 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
 1. Up to 2 inches Outside Diameter of Insulation or Pipe: ½ inch-high letters.
 2. 2-1/2 to 6 inches Outside Diameter of Insulation or Pipe: 1 inch high letters.
 3. Over 6 inches Outside Diameter of Insulation or Pipe: 2 inch high letters.
- B. Labeling shall be stenciled onto piping.
- C. Labeling shall include directional arrows.
- D. The Contractor shall use stencils to identify all such equipment using the numbering system shown on the drawings. Use oil-based enamel paint with a color that contrasts with the equipment finish. In finished areas, identify on outside surfaces. Tags may be used in areas where preferred, but only as more permanent method of attachment than glue or wire.

2.4 PIPE MARKERS

- A. Color and Lettering: Conform to ASME A13.1; "Scheme for the Identification of Piping Systems"
- B. Pipe markers installed above ceiling in return air plenums shall be plenum rated.
- C. Plastic Pipe Markers:
 1. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.
- D. Plastic Tape Pipe Markers:

1. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. Plastic Underground Pipe Markers:

1. Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mils thick, manufactured for direct burial service.

2.5 CEILING TACKS

- A. Description: Steel with 3/4-inch diameter color-coded head.
- B. Color code as follows:
 1. Plumbing valves: Green.

2.6 LABELS

- A. Description: Aluminum, size 1.9 x 0.75 inches, adhesive backed with printed identification and bar code.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.2 INSTALLATION

- A. Apply stencil painting in accordance with Division 09.
- B. Install identifying devices after completion of coverings and painting.
- C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- D. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.
- E. Install tags using corrosion resistant chain. Number tags consecutively by location.
- F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- G. Identify water heaters, pumps, tanks, and water treatment devices with plastic nameplates. Identify in-line pumps and other small devices with tags.
- H. Identify control panels and major control components outside panels with plastic nameplates.
- I. Identify valves in main and branch piping with tags.

- J. Identify piping, concealed or exposed, with plastic pipe markers or plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.
- K. Provide ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 22 0553

SECTION 22 0700 - PLUMBING INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plumbing piping insulation, jackets and accessories.

B. Related Sections:

1. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment.
2. Division 09 - Painting and Coating: Execution requirements for painting insulation jackets and covering specified by this section.

1.2 REFERENCES

A. ASTM International:

1. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
3. ASTM C450 - Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
4. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
5. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
6. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
7. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
8. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
9. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
10. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

11. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.

B. National Fire Protection Association:

1. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

C. Underwriters Laboratories Inc.:

1. UL 723 - Tests for Surface Burning Characteristics of Building Materials.

1.3 SUBMITTALS

A. Division: Submittal procedures.

B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

C. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.

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

1.4 QUALITY ASSURANCE

A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84, UL 723, and NFPA 255.

B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.

C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Applicator: Company specializing in performing Work of this section with minimum three years documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Division 01: Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
- C. Maintain temperature before, during, and after installation for minimum period of 24 hours.

1.8 FIELD MEASUREMENTS

- A. Verify all field measurements prior to fabrication.

1.9 WARRANTY

- A. Division 01: Product warranties and product bonds.
- B. Furnish one year minimum.
- C. Furnish five-year manufacturer warranty for man made fiber.

PART 2 PRODUCTS

2.1 MANUFACTURER

- A. Manufacturers for Glass Fiber and Mineral Fiber Insulation Products:
 - 1. CertainTeed.
 - 2. Knauf.
 - 3. Johns Manville.
 - 4. Owens-Corning.
- B. Manufacturers for Closed Cell Elastomeric Insulation Products:
 - 1. Aeroflex. Aerocell.
 - 2. Armacell, LLC. Armaflex.
 - 3. Nomaco. K-flex.

2.2 PIPE INSULATION

- A. TYPE P-1: ASTM C547, molded glass fiber pipe insulation.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F.
 - 2. Operating Temperature Range: 0 to 850 degrees F.

3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.
- B. TYPE P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.
 1. Thermal Conductivity: 0.27 at 75 degrees F.
 2. Operating Temperature Range: Range: Minus 70 to 180 degrees F.

2.3 PIPE INSULATION JACKETS

- A. Vapor Retarder Jacket:
 1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.
 2. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.
- B. PVC Plastic Pipe Jacket:
 1. Product Description: ASTM D1784, one-piece molded type fitting covers and sheet material, off-white color.
 2. Thickness: 15 mils.
 3. Connections: Pressure sensitive color matching vinyl tape.

2.4 PIPE INSULATION ACCESSORIES

- A. Vapor Retarder Lap Adhesive: Compatible with insulation.
- B. Covering Adhesive Mastic: Compatible with insulation.
- C. Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.
- D. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum or stainless-steel jacket single piece construction with self adhesive closure. Thickness to match pipe insulation.
- E. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.
- F. Adhesives: Compatible with insulation.
 1. Indoor Vapor Retarder Finish:
 - a. Cloth: Untreated; 9 oz/sq yd weight.
 - b. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.5 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-97.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
 - c. Marathon Industries, Inc.; 290.
 - 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 - 1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33.
 - 2. calculated per 40 CFR 59, Subpart D (EPA Method 24).
- D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Manufacturers:
 - a. Aeroflex USA Inc.; Aeroseal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. Marathon Industries, Inc.; 225.
 - 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).

- F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. Marathon Industries, Inc.; 225.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- G. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. Speedline Corporation; Speedline Vinyl Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).

2.6 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content that meets the requirement of the South Coast Air Quality Management District Rule #1168. VOC limits to be per amendment date 1/7/05.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. Marathon Industries, Inc.; 590.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-30.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-35.
 - c. Marathon Industries, Inc.; 501.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 3. Service Temperature Range: 0 to 180 deg F.
 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 5. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
1. Manufacturers:
 - a. Childers Products, Division of ITW; Encacel.
 - b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
 - c. Marathon Industries, Inc.; 570.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 3. Service Temperature Range: Minus 50 to plus 220 deg F.
 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 5. Color: White.
 6. For outdoor aluminum finish, use 60-39 mastic.

2.7 SEALANTS

- A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products - Manufacturers:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45.
 - c. Marathon Industries, Inc.; 405.

2. Joint Sealant for Polystyrene Products - Manufacturers:
 - a. Childers Products, Division of ITW; CP-70.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
 - c. Marathon Industries, Inc.; 405.
 3. Materials shall be compatible with insulation materials, jackets, and substrates.
 4. Permanently flexible, elastomeric sealant.
 5. Service Temperature Range: Minus 100 to plus 300 deg F.
 6. Color: White or gray.
 7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- B. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: Aluminum.
 6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: White.

6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).

2.8 FIELD APPLIED FABRIC – REINFORCING MASH

- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
 1. Manufacturers:
 - a. Vimasco Corporation; Elastafab 894.
- B. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
 1. Manufacturers:
 - a. Childers Products, Division of ITW; Chil-Glas No. 5.
- C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for equipment and pipe.
 1. Manufacturers:
 - a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.
 1. Manufacturers:
 - a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 SECUREMENTS

- A. Bands:
 1. Manufacturers:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015-inch-thick, 3/4-inch-wide with closed seal.
 3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 3/4-inch-wide with closed seal.
 4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
 5. Copper clad annealed steel wire having a minimum 16-gauge thickness.
- B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.
 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 3. 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.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Manufacturers:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- D. Wire: 0.080-inch nickel-copper alloy.
 1. Manufacturers:
 - a. C & F Wire.
 - b. Childers Products.
 - c. PABCO Metals Corporation.

2.11 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC per ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. 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.
- C. 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 or 316.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01: Coordination and project conditions.
- B. Verify piping and or equipment has been tested before applying insulation materials.
- C. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

- A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.
- B. Install insulation continuously through all hanger assemblies.
- C. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent

firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Division 07 for penetrations of assemblies with fire resistance rating greater than one hour.

D. Piping Systems Conveying Fluids Below Ambient Temperature:

1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

E. Glass Fiber Board Insulation

1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.

F. Hot Piping Systems less than 140 degrees F:

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
3. Do not insulate unions and flanges at equipment, but bevel and seal ends of insulation at such locations.

G. Inserts and Shields:

1. Piping 1-1/2 inches Diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.
2. Piping 2 inches Diameter and Larger: Install insert between support shield and piping and under finish jacket.
 - a. Insert Configuration: Minimum 6 inches long, of thickness and contour matching adjoining insulation; may be factory fabricated.

- b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.
 - 3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.
- H. Insulation Terminating Points:
 - 1. Branch Piping 1 inch and Smaller: Terminate hot water piping at union upstream of the control valve.
 - 2. Condensate Piping: Insulate entire piping system and components to prevent condensation.
- I. Closed Cell Elastomeric Insulation:
 - 1. Push insulation on to piping.
 - 2. Miter joints at elbows.
 - 3. Seal seams and butt joints with manufacturer's recommended adhesive.
 - 4. When application requires multiple layers, apply with joints staggered.
 - 5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.
- J. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces: Finish with PVC jacket and fitting covers.
- K. Prepare pipe insulation for finish painting. Refer to Division 09.

3.3 INSTALLATION - EQUIPMENT

- A. Factory Insulated Equipment: Do not insulate.
- B. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
- D. Equipment Containing Fluids Below Ambient Temperature:
 - 1. Insulate entire equipment surfaces.
 - 2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
 - 3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 - 4. Finish insulation at supports, protrusions, and interruptions.
- E. Equipment Containing Fluids 140 degrees F or Less:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation.
 2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
 3. Finish insulation at supports, protrusions, and interruptions.
- F. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- G. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.
- H. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.
- I. Prepare equipment insulation for finish painting. Refer to Division 09.

3.4 PENETRATIONS

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

- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies.

3.5 SCHEDULES

- A. Water Supply Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS (inches)
Domestic Hot Water Supply and Recirculation	P-1	1-1/4 inches and smaller	1.0
		1-1/2 inches and larger	1.5
Domestic Cold Water	P-1 or P-5	1-1/4 inches and smaller	0.5
		1-1/2 inches and larger	1.0

END OF SECTION 22 0700

SECTION 22 08 00 – COMMISSIONING - PLUMBING

PART 1 - GENERAL

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, system calibration, testing adjusting and balancing, performance testing and training.

MEP commissioning for this project shall be provided to fulfill the requirements of Section C408 of the North Carolina Energy Conservation Code and NC General Statute 143-135.35-.40 (SB 668). The process structure is based on ASHRAE Guideline 0-2013, ASHRAE Guideline 1.1-2007, ASHRAE Guideline 202-2013 and practices by the NEBB Commissioning Standard.

- A. Review the Owner's Project Requirements (OPR) and design team's Basis of Design (BOD) for clarity and completeness.
- B. Develop commissioning requirements to be included in the construction documents.
- C. Perform a commissioning design review of the design documents and back-check the review comments prior to submission.
- D. Develop and implement the commissioning plan.
- E. Review contractor submittals applicable to systems being commissioned for compliance with the OPR, OBD and design documents.
- F. Verify applicable equipment and systems are installed properly and receive adequate operational checkout by installing contractors.
- G. Verify and document proper performance of plumbing systems.
- H. Assist in review of O&M manuals and warranties.
- I. Develop a Systems Manual to provide future operating staff the information needed to understand and optimally operate the commissioned systems.
- J. Coordinate and verify that the Owner's operating personnel are adequately trained.
- K. Provide a summary of the commissioning activities and submit a commissioning report.
- L. Perform seasonal testing and a review of commissioned systems within the first 10-months after substantial completion.

ABBREVIATIONS

The following are common abbreviations used in the Specifications.

Cx	Commissioning
CxA	Commissioning Authority
PM	Project Manager (Owner)
A/E	Architect and Design Engineers
GC	General / Prime Contractor
EC	Electrical Contractor
PC	Plumbing Contractor
MC	Mechanical Contractor
CC	Controls Contractor
Subs	Subcontractors to General
TAB	Test and Balance Contractor
PFC	Prefunctional Checklist
FPT	Function Performance Test
Cx Plan	Commissioning Plan Document

RELATED SECTIONS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01, 22, 23 and 26 Specification Sections, apply to this section.

COMMISSIONING TEAM

- A. The members of the commissioning team consist of the Commissioning authority (CxA), the Owner Project Manager (PM), the General / prime contractor (GC), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Plumbing Contractor (PC), the Test and Balance Contractor (TAB), the Controls Contractor (CC), any other installing Subcontractors or suppliers of equipment. Additionally, if desires, the facility plant operator/engineer is also a member of the commissioning team. Representative from the A/E team may also be invited to observe critical procedures.
- B. The Contractor shall, through the GC provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Agent in demonstrating prefunctional and functional tests as they relate to each system and their technical specialty.
- C. The Commissioning Agent reserves the right to approve the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include knowledge relative to the specific equipment involved, adequate documentation, tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Agent to get the job done.

MANAGEMENT

- A. The CxA directs and coordinates the commissioning activities and the reports to the Owner. All members work together to fulfill their responsibilities and fulfill the objectives of the Contract Documents.

SCHEDULING

- A. The CxA will work with the GC to project an initial commissioning schedule. The GC will integrate the tentative commissioning schedule into the master schedule. All parties shall address scheduling problems and make necessary notification in a timely manner to avoid delaying the commissioning process. The GC will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.
- B. Functional testing will not begin until the CxA is notified in writing, by the GC that all prefunctional checklists, including startup and TAB work have been completed; and the subcontractors punch work is complete and the systems have been tested completely.
- C. The CxA will have 7 business days to review prefunctional documentation for completeness. If it is determined that the prefunctional and TAB report has not been completed and it impacts the original schedule coordinated by the CxA and GC; the schedule will be revised to include the additional days taken for the contractor to properly complete their work and the CxA to review the document.
- D. As construction progresses, more detailed schedules will be developed by the CxA and GC.
- E. Commissioning is required to be scheduled and completed prior to Substantial Completion.

COMMISSIONING PROCESS DURING CONSTRUCTION

The following narrative provides a brief overview of the commissioning tasks during construction and the general order in which they occur:

- A. Commissioning begins with a Cx kickoff meeting conducted by the CxA where the commissioning process, including Cx Plan is reviewed with the commissioning team members.
- B. Additional meetings will be required throughout construction, scheduled by the PM, CxA & GC with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
- C. Energy related equipment documentation is submitted to the CxA during the normal submittal process for review, after approval by the A/E, including start-up procedures.
- D. The CxA works with the Subs to detail start-up procedures, including providing the Subs with prefunctional checklists (PFC's) to be completed during the startup process.
- E. The TAB contractor submits their TAB plan, for approval by the CxA prior to starting TAB work.

- F. The CxA will review reports from independent testing agencies and A/E reports from on-site periodic construction observation to maintain cohesiveness with project activities.
- G. The CxA will perform site visits and document the progress of the work. An Issues / Deficiency log will be developed to track installation and coordination issues which would affect commissioning and Owner maintenance.
- H. The Subs, under their own direction, execute and document the prefunctional checklists (PFC's), including start-up and initial checkout. The CxA documents that the checklists and start-ups were completed by the Subs according to the approved plans. This will include the CxA witnessing start-up of selected (major) equipment.
- I. The CxA develops specific equipment and system functional performance test (FPT) procedures. The procedures are developed using approved shop drawings and O&M documentation supplied by the contractors.
- J. Under direction of the CxA, functional performance tests (FPT's) are executed by the appropriate sub-contractors. The results of the FPT's are documented by the CxA.
- K. With support from the TAB and CC contractors, the CxA will verify the values reported in the final TAB report.
- L. During prefunctional checkout and functional performance testing, items of non-compliance in material, installation or setup shall be corrected at the Sub's expense and the system retested.
- M. The CxA reviews the O&M documentation for completeness.
- N. The CxA coordinates and verifies training of Owner staff by vendors and sub-contractors.
- O. Deferred / seasonal / warranty testing is conducted with assistance by the appropriate Sub-contractors.

SUBMITTALS

The GC will provide the CxA a copy of the following items, for the systems to be commissioned:

- A. Construction Schedule (initial and all updates)
- B. Construction Progress Meeting Minutes (all meetings)
- C. Approved shop drawings, materials certifications and systems data for energy related systems. Approval review comments by the A/E and any resubmittal required by the A/E shall be copied to the CxA.
- D. One set of approved coordination drawings either electronic media or hard copy which includes all commissioned systems e.g. mechanical, electrical and plumbing.

- E. Piping – Plumbing contractor shall supply one copy of the piping systems pressure test results and one copy of the flushing and clean out report.
- F. Chlorination Report - Plumbing contractor shall supply one copy of the domestic water chlorination report approved by the authority having jurisdiction.
- G. Subs shall submit start-up and initial checkout plan for each piece of equipment / system as recommended by the manufacturer.
- H. Prefunctional checklist (Engineering Point-to-Point Checklist) for controls and energy related equipment as required by this specification.
- I. Operational and maintenance documentation for FPT development.

SYSTEMS TO BE COMMISSIONED

- a. Domestic hot water systems
- b. Domestic booster pumps
- c. Domestic hot water recirculating pumps
- d. Water fixtures / conservation flow devices
- e. Gas and water metering

PART 2 - PRODUCTS

TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested.
- B. All testing equipment used by the contractors shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.

PART 3 - EXECUTION

The following procedures apply to all equipment to be commissioned. This work is to be performed by the contractor or sub-contractor prior to Functional Performance Testing by the Commissioning Team.

GENERAL

- A. Cooperate with the Commissioning Authority in the following manner:
 - 1. Provide and install balancing cocks, access doors, test ports and P&T ports as required by the CxA, A/E and the Owner for functional testing.
 - 2. Allow sufficient time before final completion dates so that functional testing can be accomplished.
 - 3. Provide labor and material to make corrections when required without undue delay.

MEETINGS

- A. Prior to the start of MEP construction, the A/E, PM, CxA, and GC shall schedule, plan and conduct a commissioning kickoff meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CxA.
- B. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular subs.

START-UP AND INITIAL CHECKOUT

- A. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- B. The CxA will develop prefunctional checklists with the Contractor which indicates the required procedures to be executed as part of startup and initial checkout of the systems. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form.
- C. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
- D. The full start-up plan shall consist of:
 - 1. The CxA's prefunctional checklists.

2. The manufacturer's standard written start-up procedures copied from the installation manuals with contractor sign-off.

SENSOR AND ACTUATOR CHECKOUT AND CALIBRATION

- A. All field-installed instrumentation sensors and gages shall be calibrated. All test instruments shall have had a certified calibration within the last 12 months.
- B. Calibrate each instrumentation device by making a comparison between the display and the reading at the device, using an instrument traceable to the National Institute of Standards and Technology, which shall be at least twice as accurate as the device to be calibrated, (e.g., if field device is +/- 0.5% accurate, test equipment shall be +/- 0.25% accurate over same range). Record the measured value and displayed value for each device in the prefunctional checklist.

DDC CONTROL SYSTEM

- A. Check each physical output control point by making a comparison between the control command at the DDC system and the status of the controlled device. Check each physical output control point by making a comparison of the actual state of the device and the operator workstation graphical representation of the point condition. Record the results for each device in the Prefunctional checklist.
- B. Verify proper sequences by using the approved checklists to record results and submit the Pre-functional checklist. Verify proper sequence and operation of all specified functions.

EXECUTION OF PREFUNCTIONAL CHECKLISTS AND STARTUP

- A. Thirty (30) days prior to startup, the Subs and vendors schedule startup and checkout with the PM, GC and CxA. The execution of prefunctional checklists, startup and checkout is by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
 1. The Subs and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists, plus the final TAB report for all equipment and systems.
 2. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off.

DEFICIENCIES, NON-CONFORMANCE AND APPROVAL IN CHECKLISTS AND STARTUP

- A. The Subs (including the TAB contractor) shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and

any outstanding deficiencies shall be provided to the CxA within 1-week of test completion.

- B. The CxA reviews the report and submits either a non-compliance report or an approval form to the PM. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.
- C. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Agent will notify the Architect/Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities.
- D. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

FUNCTIONAL PERFORMANCE TESTING

OBJECTIVES AND SCOPE

- A. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- B. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, failures, interlocks, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.
- C. Demonstrate the operation of the DDC hardware, software, and all related components and systems to the satisfaction of the Commissioning Authority. Schedule the demonstration with the CxA one month in advance. Demonstration shall not be scheduled until submittals, control hardware and software, TAB Final Report, and the Prefunctional checklists are complete and approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of the

additional site visits by the Commissioning Authority for re-demonstration, the Contractor shall reimburse Owner for costs of subsequent CxA site visits.

- D. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All documentation, including as-built drawings, O&Ms, and submittals shall be at the job site before functional testing commences.

DEVELOPMENT OF TEST PROCEDURES

- A. The CxA will develop specific functional checklists test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA will provide a copy of the test procedures in advance to the Sub(s) who shall complete the tests.
- B. The Sub(s) shall review and point out to the CxA any specific problems related to the functional checklists because of feasibility, safety, equipment and warranty protection.

COORDINATION AND SCHEDULING

- A. The GC shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems.
- B. Functional testing is conducted after prefunctional and startup testing has been satisfactorily completed and non-compliance form items have been closed out. The air balancing and water balancing must be completed and debugged before CxA completes a TAB checkout of air-related or water-related equipment or systems.
- C. The CxA will schedule functional tests after written notification from the GC and affected Subs. The CxA shall direct, witness and document the functional testing of equipment and systems with support from the Subs.
- D. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

DOCUMENTATION

- A. The CxA shall witness and document the results of all functional performance tests using the specific functional checklist forms developed for that purpose. Prior to testing, these forms are provided to the GC & Subs for review.

NON-CONFORMANCE

- A. The CxA will record the results of the functional test and TAB checkout on a standard Test Form. All deficiencies or non-conformance issues will be noted and reported to the PM on a standard Issues Log.
- B. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the Test Form.
- C. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the PM.
- D. The CxA documents deficiencies and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the Issues Log report to the Sub(s), GC and/or PM. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
- E. The CxA reschedules the test and the test is repeated.
- F. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1. The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the PM, the GC and to the Sub representative assumed to be responsible.
 - 2. Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.
 - 3. The CxA documents the resolution process.
 - 4. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA & GC reschedules the test and the test is repeated until satisfactory performance is achieved.

COST OF RETESTING

- A. The contractor and Subcontractors will notify the CxA that the systems are ready for testing. As such, for a given system it assumed that all specified prefunctional tasks are complete by the contractor or Sub.

- B. If the CxA discovers that the systems are incomplete at the time of the first functional test, the entire system will be marked as deficient and the retesting procedure for deficient systems will be followed.
- C. Deficiencies will be noted by the CxA and documented. Deficiencies are associated with completed systems. For deficiencies not related to any prefunctional checklist or start-up fault, the following shall apply:
 - i. The CxA will conduct retesting (back-check) of the equipment / system once at no charge to the GC for their time.
 - ii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting beyond the initial retesting noted above will be chargeable to the GC.
 - iii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting for items which are a repeated deficiency, previously reported via commissioning deficiency log will be chargeable to the GC.
 - iv. The Contractor shall respond in writing to the CxA and PM at least as often as non-compliance reports (Cx Issues Log) are issued. The response shall report the status of each apparent outstanding discrepancy identified during commissioning. Responses shall cover explanations of any disagreements and proposals for their resolution.
 - v. The CxA retains the original non-conformance form (Cx Issues Log) until the end of the project.
 - vi. The GC shall not consider any required retesting by any Contractor a justified reason for a claim of delay or for a time extension.

APPROVAL

- A. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA, if necessary. The CxA recommends acceptance of each test to the PM using a standard form. The PM gives final approval on each test using the same form, providing a signed copy to the CxA and the Contractor.

OPERATION AND MAINTENANCE MANUALS (O&M'S)

- A. The contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned sixty (60) days in advance of functional testing.
- B. Operation and Maintenance manuals shall conform to requirements detailed in Specification 01 78 00.

OWNER TRAINING

- A. The GC shall be responsible for training coordination, agendas, scheduling and ultimately for ensuring that training is complete per Specification 01 79 00.
- B. The CxA shall be responsible for overseeing and approving the adequacy of the training of Owner personnel for commissioned equipment.
- C. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors are specified in Division 01, 22, 23 and 26.
- D. Each Sub and vendor responsible for training shall submit a written training plan (agenda) to the CxA for review and approval prior to training. The plan shall include the following elements:
 - 1. Equipment (included in training)
 - 2. Intended audience
 - 3. Location of training
 - 4. Objectives
 - 5. Subjects covered (description, duration of discussion, special methods, etc.)
 - 6. Duration of training on each subject
 - 7. Instructor for each subject
 - 8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
- E. The CxA will verify the training was satisfactorily completed and recommend approval of the training to the PM.

WARRANTY AND DEFERRED TESTS

- A. Warranty system testing (10 months after project acceptance) will be conducted and require assistance from the appropriate sub-contractors. Each sub will meet with facility staff to discuss the current building operation and the condition of outstanding issues related to the original commissioning. Problems or concerns they have with operating the building as originally intended will be reviewed, tested and action developed.
- B. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM, A/E, and CxA. These tests will be conducted in the same manner as the seasonal tests as soon as possible.

SEASONAL TESTING

- A. During the warranty period, seasonal testing shall be completed as part of this contract. Seasonal testing is intended to test the performance of systems under full load conditions that cannot be simulated during the functional testing period. For example, it is impossible to test the heating system under full load conditions in July, so the heating system would be full load tested during the winter months. The CxA shall coordinate

this activity. Tests will be executed, documented, and deficiencies corrected by the appropriate Subs, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the GC.

END OF COMMISSIONING SPECIFICATION SECTION

SECTION 22 3010 - PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 22 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 22 sections contain statements more definitive or more restrictive.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Water Heaters
 - 2. Pumps
 - 3. Expansion Tanks
- B. Related Sections include the following:
 - 1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
 - 2. Section 22 05 23 – General-Duty Valves for Plumbing Piping
 - 3. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment
 - 4. Section 22 07 00 – Plumbing Insulation
 - 5. Section 22 42 00 – Plumbing Fixtures

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 220500 – Plumbing General.
- B. The Contractor shall submit manufacturer's catalog data for the following:
 - 1. Water Heaters
 - 2. Pumps
 - 3. Expansion Tanks
- C. The Contractor shall submit Operation and Maintenance Data in accordance with Section 220500 for the following:
 - 1. Water Heaters
 - 2. Pumps

PART 2 - PRODUCTS

2.1 WATER HEATERS

- A. General

1. Packaged water heater systems shall be furnished factory wired and UL listed. Final electrical connections shall be provided as indicated in Division 26.
2. Storage tanks shall be insulated so that the maximum heat loss of the tank does not exceed 14 BTUH per square foot of tank surface area or the current ASHRAE 90 standard, whichever is more stringent.
3. Water heater systems shall meet current ASHRAE 90A efficiency requirements.
4. Packaged water heater located in food preparation or food storage areas shall be National Sanitation Foundation certified and bear the NSF label.
5. Provide the services of a manufacturer's representative experienced in the installation and operation of this equipment for not less than one workday on-site for installation inspection, startup, and instruction of owner's personnel.

B. Electric Storage Water Heaters

1. The water heater shall have a modulating input rating and recovery capacity as indicated on the drawings. Heater to be completely insulated and jacketed for vertical installation. The jacket shall be a round heavy gauge galvanized steel assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mills. Jacket shall have a full-length element access panel and a hinged control panel access door for safety. The jacketed tank assembly shall have an accessible drain. The tank shall be factory insulated with a 3 inch thick high-density non-CFC polyurethane foam to meet the minimum stand-by loss requirements of the latest edition of ASHRAE 90.1 Energy Efficiency Standards.
2. The tank shall be of standard construction in accordance with ASME Boiler and Pressure Vessel Code requirements and shall be stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors. The tank shall be standard with a 150 psi working pressure for 5 through 50 gallon models and 125 psi working pressure for 65 through 120 gallon models. The tank shall be glass lined with vitreous glass enamel and fired at 1600°F to ensure a molecular fusing of glass and steel. A combined magnesium tank saver anode with a powered anode shall be installed in the tank for corrosion protection. A handhole clean-out shall be standard on all models to allow inspection and cleaning of the vessel. Tank inlet and outlet water connections shall be 1-1/2" NPT.
3. The immersion heating elements shall be low watt density with a incoloy sheath for long life. The heating elements shall mount in individual screw-in tank flanges. In accordance with U.L. requirements, water heaters with a current draw in excess of 120 amps shall be equipped with internal fusing.
4. All field electrical wiring connections to the water heater shall be made to a main terminal block. All internal wiring shall be made to solderless terminal lug wiring connections. Wiring to be color coded for ease of servicing. An ASME rated

temperature and pressure relief valve shall be provided with the water heater. The water heater shall be factory assembled, wired and tested. The entire water heater shall be U.L. Listed and provided with a 3-year limited warranty on the tank and a 1 year limited warranty on parts.

5. Immersion Thermostats and Contactors – Heating elements shall be switched by a magnetic contactor(s) operated by a fused 120-volt control circuit with an advanced electronic control. The electronic control shall have an LCD readout which will display operational and diagnostic information. Standard features include: Low Water Cutoff, Element Sensing and Night Setback. The control shall be capable of supplying 180°F water. The control circuit shall use a built-in transformer to reduce line voltage to 120 volts for operation of the control circuit components. The control circuit shall include a manual reset safety hi-limit control to prevent over heating in the event of a component failure.

6. Approved manufacturers: Lochinvar, A.O. Smith, Bradford White.

2.2 PUMPS

- A. Hot Water Recirculation Pumps shall have capacities and motor HP as noted on the drawings. Pump shall be of all bronze construction and shall be furnished with companion flanges. Pump assembly shall be provided with isolation valves, check valve, two test plugs for insertion of pressure gauges and temperature sensor. Temperature sensor shall be connected to Building Automation System (BAS). BAS system shall cycle pump on and off as indicated on the mechanical drawings.

1. Approved Manufacturers: Bell & Gossett, Taco, Grundfos

2.3 EXPANSION TANK

- A. Pre-pressurized diaphragm type steel expansion tank. Tank shall conform to ASME Section VIII construction for 125 psig, (200 psig WOG), tank shall have rigid polypropylene lining for corrosion control, butyl rubber diaphragm. Provide pressure gauge on system connection piping.
- B. Thermal expansion tank shall be installed to absorb expansion from hot water generator and storage tanks under no-flow or low-flow conditions. System connection shall not be located upstream of check valves or regulating valves or downstream of mixing valves or in a manner that shall negate this purpose.
- C. Thermal expansion tank pressurization shall be field charged to match the domestic water system pressure when pumps are energized and when water temperature in storage tank is at 40 to 80°F temperature. Acceptance volume shall be based upon the difference between system pressure and temperature relief valve pressure.
- D. Approved Manufacturers: Amtrol, Bell & Gossett, Wessels

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment, piping and accessories shall be installed in strict accordance with manufacturer's requirements.
- B. Water heaters exceeding heat input capacity of 200,000 BTUH (58.6 KW) or nominal water capacity of 120 gallons fall are under the jurisdiction of the North Carolina Department of Labor in accordance with General Statute Chapter 95, Article 7A, Section 95-69 10. The Contractor shall obtain NC DOL inspection and approval for water heaters meeting one of the criteria listed above.
- C. Water heaters which are not provided with recirculating piping system shall be provided with heat trap type of piping arrangement on the hot water outlet of the water heater.
- D. Drain and thermal purge from all pumps shall be extended to within 4 inches of floor drain.
- E. Water heater relief valves shall be piped as indicated or to a point which will not cause personal injury or property damage and shall be readily observable by the building occupants.
- F. Water heaters or storage tanks located in areas where leakage of the tanks or connection will cause damage shall be provided with galvanized steel pan.
- G. Provide isolation valves for all equipment and accessories.
- H. Unions shall be provided adjacent to all equipment or wherever necessary to facilitate the removal of equipment for repair or replacement. Unions for copper tubing up to and including 2-inch diameter shall be brass ground joint with socket ends for solder. Unions for copper tubing 2-1/2 inches in diameter and over shall be standard brass flanges and so stamped. No lip type unions or long screws will be permitted. The contractor shall furnish and install all structural steel angles, channels, etc. necessary to properly support all fixtures and equipment to the satisfaction of the Professional.
- I. Furnish and install isolation valves at the cold water and hot water supply tapplings and an AGA/ASME pressure and temperature relief valve for each water heater.
- J. The drawings are diagrammatic in showing plumbing equipment layout. Variations in differing manufacturer's piping arrangements and physical equipment size require careful layout by the Contractor. The Contractor shall coordinate his layout so as to provide adequate clearances to allow for maintenance and inspection. In particular, equipment supports shall not obstruct floor drains or utility trench access and piping shall be installed to allow sufficient vertical clearance above treatment tanks.

END OF SECTION 22 3010

SECTION 22 4200 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 22 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 22 sections contain statements more definitive or more restrictive.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Water Closets
 - 2. Urinals
 - 3. Lavatories
 - 4. Sinks
 - 5. Electric Water Coolers
- B. Related Sections include the following:
 - 1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
 - 2. Section 22 05 15 – Plumbing Specialties
 - 3. Section 22 05 23 – General-Duty Valves for Plumbing Piping
 - 4. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment
 - 5. Section 22 07 00 – Plumbing Insulation
 - 6. Section 22 30 10 – Plumbing Equipment

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 220500 – Plumbing General.
- B. The Contractor shall submit manufacturer's catalog data for the following:
 - 1. Water Closets
 - 2. Urinals
 - 3. Lavatories
 - 4. Sinks
 - 5. Electric Water Coolers
 - 6. Flush Valves
 - 7. Toilet Seats
 - 8. Fixture Carriers
 - 9. Faucets and Mixing Valves

- C. The Contractor shall submit Operation and Maintenance Data in accordance with Section 220500 for the following:
 - 1. Electric Water Coolers
 - 2. Flush Valves
 - 3. Faucets and Mixing Valves

PART 2 - PRODUCTS

2.1 GENERAL

- A. All fixtures shall be furnished complete with traps, faucets, wastes, supplies with stops, etc., as required. All exposed metal parts shall be chromium plated.
- B. Fixtures and equipment shall be those of reputable manufacturers and shall be new and the best of their respective kinds.
- C. All fixtures and equipment of similar types shall be of the same manufacturer unless indicated otherwise on the drawings or specified herein.
- D. Fixtures shall be mounted at mounting heights as indicated.
- E. If fixtures and equipment indicated in the Contract Documents are not currently manufactured, the manufacturer's current equivalent to the indicated fixtures and equipment shall be provided at no additional cost, subject to review and acceptance by the Professional.

2.2 PLUMBING FIXTURES

- A. See Plumbing Fixture Schedule on Drawings for Fixture Specification. Manufacturers shall be equal to those listed on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixtures and equipment shall be installed in a neat and workmanlike manner and in accordance with the manufacturer's recommendations. The quality of installation shall be subject to the approval of the Professional.
- B. All wall mounted lavatories, chair carriers and supports shall be suitable to the type of construction wherein they are located. Urinals and water closets shall be supported by chair carriers.
- C. All fixtures and equipment must be protected against damage during the progress of construction. Upon completion of construction, all fixtures and equipment must be thoroughly cleaned and left in perfect working order. All piping and accessories having polished, plated or finished surfaces shall be protected to prevent scarring or other damage and protect the finish against damage.

- D. Provide isolation valves for all fixtures, equipment, and accessories.
- E. All fixture supplies and waste lines shall be run to wall unless construction requires, they be run to floor. All supplies through walls shall be provided with angle stops. All supplies through floors shall be provided with straight stops. Unions shall be provided adjacent to all equipment or wherever necessary to facilitate the removal of equipment for repair or replacement. Unions for copper tubing up to and including 2-inch diameter shall be brass ground joint with socket ends for solder. Unions for copper tubing 2-1/2 inches in diameter and over shall be standard brass flanges and so stamped. No lip type unions or long screws will be permitted. The contractor shall furnish and install all structural steel angles, channels, etc. necessary to properly support all fixtures and equipment to the satisfaction of the Professional.
- F. Drain piping from all backflow preventers, relief valves and vents, drain down connections, kitchen equipment, etc. shall be extended to within 4 inches of a floor sink or floor drain unless otherwise directed.
- G. Mop receptor drains shall be sized for the outlet pipe size shown on drawings and shall be equipped with P-traps. The Contractor shall be responsible for proper height setting and leveling of drains.
- H. Water closet floor flanges shall be cast iron, screwed or caulked, not less than 1/4 inch thick; not less than 2 inches caulking depth. Bolted with approved gasket between closet bowl and flange. Closet screws shall be of brass. The use of commercial putty or plaster for setting closet bowls is prohibited.
- I. Apply a bead of waterproof caulking around the edge of surface mounted plumbing fixture to mask any irregularities between the fixture and wall finish. Color of caulk shall match the fixture color.

3.2 MOUNTING HEIGHTS

- A. Plumbing fixture mounting heights shall be as indicated on the drawings. Mounting heights for barrier free fixtures shall meet the requirements of the ADA Accessibility guidelines. These guidelines shall apply unless superseded by more stringent State or Local requirements.

END OF SECTION 22 4200

SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 RELATED PROVISIONS

- a. The requirements of the general conditions and of Division 01 apply to that portion of the work specified in this section.
- b. These specifications and the accompanying drawings shall include the furnishing of all labor, tools, materials, fixtures, transportation, appurtenances and service necessary and incidental to the installation of a complete and operative system as indicated and intended on the Drawings and as herein specified.
- c. Contractor shall coordinate the work and equipment of this division with the work and equipment specified elsewhere in order to assure a complete and satisfactory installation. Work such as excavation, backfill, concrete, flashing, etc., which is required by the work of this Division of the Specifications, shall be provided by this Division unless otherwise indicated.
- d. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

1.2 DESCRIPTION OF THE WORK

- a. Work included under this Division includes installation of a new cooling and heating system and associated electrical system and controls system. The systems shall be installed complete, with boilers, piping, chiller, pumps and auxiliaries as hereinafter called for. Miscellaneous items including conduits, concrete slab, etc., are to be provided as indicated.
- b. It shall be the responsibility of the Contractor to provide a complete and operating system according to the true intent and meaning of the plans and specifications and all pipe, controls and equipment, etc.

1.3 DEFINITION

- a. The word "Contractor" as used in this Section of the Specifications refers to the HVAC Contractor unless specifically noted otherwise. The word "provide" means furnish, fabricate, complete, install, erect, including labor and incidental materials, necessary to complete in place and ready for operation or use the items referred to or described herein, and/or as shown or referred to on the Contract Drawings.

1.4 HVAC CONTRACTOR'S QUALIFICATIONS

- a. It is assumed that the contractor has had sufficient general knowledge and experience to anticipate the needs for a construction of this nature. The contractor shall furnish all items required to complete the construction in accordance with reasonable interpretation of the intent of the Drawings and Specifications. Any minor items required by Code, law or regulations shall be provided whether or not specified or specifically shown.
- b. All work must be done by first class and experienced mechanics properly supervised, and it is understood that the Engineer has the right to stop any work that is not being properly done and has the right to demand that any incompetent workman be removed from the job and a competent workman be substituted therefor.
- c. All work must be done in strict accordance with standards of AME, ASHRAE and the building laws of all character in force in the locality where the apparatus is being installed. All work must also be in accordance with rules and regulations of the National Board of Fire Underwriters.

1.5 DUTIES OF CONTRACTOR

- a. Contractor is responsible for familiarizing himself with the details of the construction of the building. Work under these specifications installed improperly or which requires changing due to improper reading or interpretation of building plans shall be corrected and changed as directed by Engineer without additional cost to the Owner.
- b. Contractor shall leave the premises in a clean and orderly manner upon completion of work and shall remove from premises all debris that has accumulated during the progress of the work. The HVAC Contractor shall have the permanent HVAC systems in sufficient readiness for furnishing temporary climatic control at the time the building is enclosed. The HVAC systems control shall maintain climatic control throughout the enclosed portion of the building sufficient to allow completion of the interior finishers of the building. A building shall be considered enclosed when it has windows installed and when doorways and other openings have protection which will provide reasonable climatic control. The appropriate climatic condition shall be jointly determined by the Contractor and the Architect. Use of the equipment in this manner shall in no way affect the warranty requirements of the Contractor.

1.6 CODES, RULES, PERMITS AND FEES

- a. The contractor shall give all necessary notices, obtain all permits and pay all government sales taxes, fees and other costs including utility connections or extension, in connection with his work; file all necessary plans, prepare all

documents and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates for inspection for his work and deliver same to the Architect before request for acceptance and final payment for the work.

- b. The contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, ordinances, rules and regulations as required to complete the project in accordance with the intent of the drawings.
- c. All materials furnished, and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of all governmental departments having jurisdiction.

1.7 SURVEYS AND MEASUREMENTS

- a. The contractor shall base all measurements, both horizontal and vertical, from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at the site and check correctness of same as related to the work.
- b. Should the contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and Specifications, he shall notify the Architect and shall not proceed with his work until he has received instructions from the Architect.

1.8 PLANS

- a. Except where dimensions are shown, mechanical plans are diagrammatic; see Architectural drawings for building dimensions and locations of windows, doors, ceiling diffusers, lights, etc. The plans are not intended to show each and every fitting, valve, pipe or pipe hanger, or a complete detail of all the work to be done but are for the purpose of illustrating the type of system, pipe and duct sizes, etc. and special conditions considered necessary for the experienced mechanic to take off his material and lay out his work. Contractor shall be responsible for taking such measurements as may be necessary at the job and adapting his work to the local conditions.

1.9 DRAWINGS AND SPECIFICATIONS

- a. Plans are diagrammatic, and it sometimes occurs that conditions exist in buildings which require certain changes in drawings and specifications. In event that such changes are necessary, the same are to be made by Contractor without expense to the Owner, provided however, that such changes, do not require furnishing more

material or performing more labor than the true intent of the drawings and specifications demand.

- b. It is understood that while the drawings are to be followed as closely as circumstances will permit, the Contractor is held responsible for the installation of the system according to the true intent and meaning of the drawings. Anything not entirely clear on the drawings or in the specifications will be fully explained if application is made to the Engineer. Should however, conditions arise where in the judgment of the Contractor certain changes would be advisable. Contractor will communicate with Engineer and secure approval of the changes before going ahead with the work.
- c. The electrical and mechanical systems for this job have been designed on the basis of the mechanical equipment listed or data given herein or on the drawings. It shall be the responsibility of the Contractor to determine that the electrical service outlets, wiring, conduit and all overcurrent protective and safety devices furnished are adequate to meet Code Requirements for the equipment which he proposes to use. Changes required in the electrical system to accommodate the proposed mechanical equipment shall be worked out and the details submitted for approval. The cost of making the necessary changes to the electrical system shall be the responsibility of the Contractor.

1.10 SHOP DRAWINGS

- a. Refer to Division 01.
- b. All items submitted to Architect for review shall bear stamp or notation indicating contractor's prior review and approval.
- c. Any Electrical or other changes required by substituted equipment to be made at no change in contract price.
- d. Submit manufacturer's certified performance data for all equipment.
- e. Coordinate installation drawings with other parts of the work, whether specified in this Division or other Divisions.
- f. Approval of shop drawings by the Engineer shall not relieve the Contractor from his obligation to provide equipment, control, and operation to the true intent of plans and specifications.
- g. The Contractor shall submit to the Engineer, within ten (10) days after approval of bids by the owner, a list indicating the manufacturer of all equipment and materials which he proposes to use. After that date, no substitution will be approved, and all items shall be as specified.

1.11 COORDINATION DRAWINGS

- a. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 2. Roof framing and support members relative to duct penetrations.
 - 3. Ceiling suspension assembly members.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

1.12 SCAFFOLDING, RIGGING, HOISTING

- a. This contractor shall furnish all scaffolding rigging, hoisting, and services necessary to erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required.

1.13 FOUNDATIONS, SUPPORTS, PIERS, ATTACHMENTS

- a. Contractor shall furnish and install all necessary foundations, supports, pads, bases and piers required for all air conditioning equipment, piping, pumps, tanks, compressors, and for all other equipment furnished under this contract.

1.14 SLEEVES AND OPENINGS

- a. Contractor must have an experienced mechanic on the job before concrete slab floors or concrete masonry walls are poured or built into place, whose duty it shall be to locate exact positions of any and all holes necessary for future installation of his pipe work, ducts or equipment. Where pipes pass through concrete or masonry walls or floors, steel pipe sleeves shall be furnished. These shall be the same length as wall thickness and shall extend 1/2" above finished floors. Pipe sleeves in equipment room floors shall extend 3" above refinished floor. Pipe sleeves in equipment room floors shall extend 3" above finished floor. Sleeves shall be placed in position by this Contractor.
- b. This Contractor shall arrange for proper openings in the building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, portions cut must be restored to their former condition by this Contractor.
- c. This Contractor will provide duct openings or chases in masonry or concrete; however, it is this Contractor's responsibility to advise exact dimensions, shape and locations of openings required in sufficient time for the Contractor to make

necessary provisions. This Contractor shall be responsible for correct size and location of each opening for his equipment through these openings.

- d. Wall openings that require a fire or smoke damper shall be made as nearly possible to the damper or duct size so that an angle frame can close the opening entirely.
- e. Where pipes or ducts penetrate floors or partitions which are fire or smoke barriers, the integrity of the barrier shall not be compromised by such penetration.

1.15 CUTTING AND PATCHING

- a. The Contractor shall do all cutting, fitting and patching as required to install piping and equipment except openings through the roof shall be provided by the General Contractor. Patching shall be done by mechanics skilled in the various trades and work shall match the existing work.
- b. All exposed openings in walls and floors for piping shall be core drilled. Cutting of holes by hand will not be allowed.
- c. Provide all required protection including but not limited to, welding blankets, dust covers, shoring bracing and supports to maintaining structural integrity, safety and cleanliness of the work.

1.16 EXCAVATION AND BACKFILLING

- a. All excavation and backfilling, puddling and tamping required to properly install work under this contract shall be done by this Contractor.
- b. Trenches shall be on an even grade and firmly packed to form a solid foundation for laying piping. The Contractor is cautioned to comply with the North Carolina Department of Labor requirements concerning shoring for excavations.
- c. Backfill shall be clear of rocks and trash. Backfilling shall be water tamped so as to provide firm footing for finish work and shall be maintained at proper level for duration of the Contract. No backfilling shall be done until work to be covered has been inspected. Excessive excavation material shall be deposited on site and leveled as directed by the engineer.

1.17 POURED IN PLACE CONCRETE WORK

- a. Furnish and install all concrete work required for the construction of anchors, guide bases and elsewhere as indicated on the Drawings. Refer to appropriate Section in Division 3 for specification requirements.

PART 2: PRODUCTS

2.1 MATERIALS

- a. Provide equipment complete with all components and accessories necessary to its satisfactory operation.
- b. Listing of a manufacturer's name in this Division does not infer conformity to all requirements of the Contract Documents, nor waive requirements thereof.

PART 3: EXECUTION

3.1 BELT DRIVES

- a. V-belt drives shall be rated at not less than 200% of nominal motor horsepower.
- b. Motor sheaves shall be fixed pitch type.
- c. Scheduled fan static pressures are estimated. Provide one extra drive per device as required to allow adjustment to deliver scheduled air quantities against actual system resistance.
- d. Provide guards for all belt drives not enclosed within equipment housings. Provide openings in guard at driving and driven sheaves for use of revolution counter.

3.2 MAINTENANCE AND OPERATING INSTRUCTIONS

- a. Upon completion of all work, the Contractor shall furnish a complete set of operating instructions for all equipment. Such instructions shall be diagrammatic in form on heavy white paper, suitably framed, protected with glass and hung where directed by the owner. A preliminary draft of the instruction sheets shall be submitted to the engineer for approval before making same.
- b. Manufacturer's instruction books, card, etc., (to each individual piece of equipment furnished under this contract) shall be furnished to the owner. These shall contain instructions for the operation and maintenance of all equipment. Where such is not furnished by the manufacturer, the contractor shall give written instructions to the owner for the maintenance of the equipment involved.

3.3 DUCTS, PLENUM, ETC.

- a. As indicated on drawings, provide a system of ducts for supplying returning and exhausting air from various spaces. All details of the ductwork are not indicated, and the necessary bends, offsets and transformations must be furnished whether shown or not.

- b. All sheet metal ducts, casing, plenums, etc., of sizes indicated, shall be constructed from prime galvanized sheet steel, and shall be in accordance with or equal to standards set forth in latest issue of SMACNA low velocity duct manual for gauges of materials, (2" pressure), workmanship, method of fabrication and erection.
- c. All uninsulated panels of ducts over twelve inches (12") wide shall be cross-broken, except on plenums, which shall be braced with angle iron as required to prevent breathing.
- d. All ductwork must present a smooth interior and joints must be airtight. Where there is evidence of undue leakage at the joints in low pressure ducts, they shall be sealed with cement similar to Foster 30-02.
- e. Depending upon space requirements, round or square elbows may be used as required or at the Contractors option in low velocity ducts. All elbows shall be constructed for minimum pressure drop. All elbows with an inside radius less than 3/4 the width of the duct must be fitted with multiple double thickness turning vanes.
- f. No transformations or offsets shall be made with a slope greater than (7 to 1), space conditions permitting.
- g. Where indicated on drawings, ductwork is to be lined with flexible fiberglass acoustics material weighing not less than 1 1/2 lb. per cubic foot and having a flame spread classification of not more than twenty-five (25) as listed under Underwriters Laboratories. Liner shall be applied according to SMACNA duct liner standard. Thickness shall be as indicated on the drawings. Duct sizes on plan are inside clear sizes, increase the actual sheet metal size accordingly in sizing the duct.
- h. The lining shall be secured to the ductwork with a suitable adhesive and with mechanical fasteners center. Liner shall be cut such that adjacent sections of insulation butt together and are sealed with Foster 30-02 joints.
- i. All duct connections to and from all centrifugal fans or cabinets containing fans, shall be made with fabric equal to "Ventfab" as made by Ventfabrics, Inc., not less than four inches (4") long secured by peripheral iron straps holding fabric in galvanized iron, except as otherwise noted.
- j. Vertical ducts shall be supported by means of an angle iron frame riveted to the ductwork on at least two (2) sides. Horizontal runs of ductwork shall be supported on not more than 8'-0" centers as required.
- k. Manual volume and splitter dampers shall be furnished and installed where shown and where necessary for proper regulation of the air distribution. A quadrant and

set screw equal to "Ventlock" #641 shall be installed for all dampers which are concealed above plaster or gypsum board ceilings, or behind the masonry construction, furnish and install concealed regulators ("Ventlock" #666) with chrome cover plate.

- l. All ductwork shall operate without chatter and vibration and shall be free from pulsations.
- m. See section 233113 for metal ductwork requirements.

3.4 ACCESS DOORS OR PANELS

- a. Provide duct access doors of approved construction at any apparatus requiring service and inspection. Doors shall suit finish in which installed.
- b. Access doors in rated walls or assemblies shall be rated as required to maintain rating of assembly. Rated access doors shall bear U.L. Label.

3.5 CLEANING DUCT SYSTEM

- a. Upon complete installation of ducts, clean entire system of rubbish, plaster, dirt, etc., before installing any outlets. After installation of outlets and connections to fans are made, blow out entire systems with all control devices wide open.

3.6 ITEMS OF ELECTRICAL EQUIPMENT

- a. All electrical work shall be done by properly licensed electrical mechanics in accordance with Division 26 of the specifications under supervision of a licensed Electrical Contractor as approved by the Architect.
- b. The Electrical Contractor shall provide all power wiring to motor starter and/or disconnect switch and from starter/disconnect switch to motor. The Mechanical Contractor shall provide all control wiring, low voltage or line voltage, as required for the operation of all mechanical equipment. All control devices such as motor starters, thermostats, switches, etc. shall be provided by the Mechanical Contractor.
- c. All motor starters shall be provided with a "hand-off-auto" switch on the starter cover.
- d. All items of mechanical equipment electrically operated shall be in complete accordance with electrical division of the specifications. Mechanical equipment, other than individually mounted motors, shall be factory prewired so that it will only be necessary to bring connections to a single set of terminals.

- e. Mechanical equipment electrical components shall all be bonded together and connected to electrical system ground.
- f. All mechanical equipment shall be completely U.L. listed and labeled as a complete package, not through individual components or parts. Provide required field UL listing services as required to comply.

3.7 WARRANTY AND SERVICE

- a. Upon completion of all work, the contractor shall check the system out so that all motor bearings are greased as required and have all systems balanced. He shall be responsible for original service, of starting the system up, and providing one set of replacement filters after final acceptance.
- b. All equipment shall carry a full one - year warranty with a five - year warranty on the cooling cycle on all packaged type equipment in accordance with Division 01 of the specifications.

3.8 INSPECTION AND ACCEPTANCE TEST

- a. The project will be checked periodically as construction progresses. The contractor shall be responsible for notifying the Engineer at least 48 hours in advance when any work to be covered up is ready for inspection. No work will be covered up until approved by the Engineer.
- b. Upon completion of erection of all equipment and work specified herein and shown approved shop drawings, and at the time designated by the engineer, the contractor shall start all apparatus, making necessary tests as directed and as specified herein, and make adjustments of all parts of all equipment before acceptance of equipment by the owner. The contractor must demonstrate to the owner, by performance, that all equipment operates as specified and meets the guarantee called for.
- c. Tests shall include satisfactory evidence that all systems operate as called for on the drawings, and that all pieces of equipment operate at specified ratings under specified operating conditions.
- d. The contractor shall furnish all fuel and power required for these purposes and provide the proper and necessary help required to operate the system while tests are being made.

- e. All drainage piping shall be tested by filling with water to a point 10' above the underground drains or to point of discharge to grade and let stand thus filled for 3 hours.
- f. Tests on all pipe work shall be subject to the inspection of the Engineer. He shall be given 24-hours notice when a section pipe is to be tested and the test shall not be removed until permission is given by the Engineer.

3.9 AS-BUILT DRAWINGS

- a. This contractor shall keep on the job at all times, a clean set of contract drawings in blueprint form. As the job progresses, any and all deviations from the arrangements, piping runs, equipment locations, etc., shown on the bid prints shall be marked on this set with red ink. These prints shall not be used for any other purpose than to be marked up as "As-Built" Drawings.

3.10 OWNER TRAINING

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain the equipment listed below:
 - 1. VRF
 - 2. DDC Control Systems
 - 3. DOAS
- B. Extent of Training:
 - 1. Base extent of training on scope and complexity of equipment installed and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 - 3. Minimum Training Requirements:
 - a. Provide not less than the number days of training indicated below.
 - 1) VRF Systems – 1 day (8 hours)
 - 2) DDC Control Systems - 2 days (16 hours)
 - 3) DOAS - 1 day (8 hours)
 - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
- C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
 2. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions.
 3. Provide staggered training schedule as requested by Owner.
- D. Training Attendee List and Sign-in Sheet:
1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
 2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
 3. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
 4. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.
- E. Attendee Training Manuals:
1. Provide each attendee with a color hard copy of all training materials and visual presentations.
 2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.
- F. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
- G. Training Outline:
1. Submit training outline for Owner review at least 10 business day before scheduling training.
 2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

H. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

I. Training Content:

1. Basic operation of each system.
2. Understanding each unique product type installed including performance and service requirements for each.
3. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.

END OF SECTION 26 0500

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined *10 CFR Part 431* published by the US Department of Energy
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

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

2.6 VARIABLE FREQUENCY DRIVES

A. Scope

- a. This section provides requirements for AC inverter type adjustable frequency, variable speed drives or herein identified as AC drives for use with (NEMA B, NEMA A, NEMA C, NEMA E, synchronous) design AC motors.
- b. All cabling from VFDs feeding associated equipment shall consist of 3-phase, 3 ground, copper tape spiral shield, galvanized steel interlocked armor cable.

B. Manufacturers

- a. The manufacturer of the AC drive shall be a certified ISO 9001 quality facility. ABB, Danfoss (Graham), Eaton, Emerson, Johnson Controls or prior approved equal meeting the requirements of this section.
- b. All VFD's in project shall be by the same manufacturer. This shall include all pumps and air handler fans, where indicated on the plans.

C. Regulatory Requirements

- a. UL listed.
- b. EN Standard CE marked for the following:
Low Voltage Directive (73/23/EEC)

EN50178

EMC Directive (89/336/EEC)

EN61800-3 Adjustable Speed electrical power drive systems Part 3

- c. Designed, constructed and tested in accordance with NEMA, ICS, NFPA and IEC standards.

D. Environmental Requirements

- a. The AC drive construction ½ hp to 5 hp 230V and 1 hp to 7.5 hp 480V shall be IP20/open according to Standard EN50178. 7.5 hp to 10 hp 230V and 10 hp to 20 hp 480V shall be Type 1. Both are designed to operate as Pollution degree 2 conforming to IEC 664-1, EN50718 and NEMA ICS-1. Drives above 20 hp 480V and 15 hp 230V shall meet Type 1 Pollution degree 3 according to IEC 664-1, EN50718 and NEMA ICS-1.
- b. The AC drive will be designed to operate in an ambient temperature from 0 to 40 degrees C (32 to 104 degrees F).
- c. The storage temperature range shall be -25 to 70 degrees C.
- d. The maximum relative humidity shall be 95% at 40 degrees C, non-condensing.
- e. The AC drive will be rated to operate at altitudes less than or equal to 1000m (3300 ft).
- f. The AC drive will meet the IEC 68-2-6-vibration specification.
- g. The AC drive shall be designed and constructed to be of finger safe construction with enclosure open to operator access according to IP20 standards.

E. Related Document

- a. Division 26 – Electrical

F. Equipment

- a. General Description
 - i. The AC drive shall utilize soft switching technology and voltage vector control.
 - ii. The AC drive shall have the Hand/Off/Auto function.
 - iii. The AC drive shall have a VFD/bypass system design that is serviceable while operating in bypass mode. This includes a drive disconnect to ensure service personnel safety, a 2-contactor bypass for full speed operation, and an isolation barrier to ensure service personnel safety and repair of the drive while operating in full speed bypass mode. Bypass shall have a separate integral disconnect.
 - iv. Each AC drive shall have voltage/single phase protection of the drive and bypass system to ensure continued operation after utility power failures. Drive protection modules shall be ATC Diversified Electronics SLU-100-ASA 0315PB or equivalent. Protection modules shall monitor incoming 480V 3-phase power and shall interrupt 120V control circuit. Install modules in drive cabinet.

- v. The AC drive shall have common control in both drive and bypass modes.
- vi. Each AC drive shall have M.O.V. lightning protection.
- vii. The AC drive shall have safety interlocks for all modes of operation.
- viii. A manufacturer's warranty shall be provided on all materials and workmanship of no less than 1 year from the date of start-up or 18 months from date of shipment.

b. Ratings

- i. The AC drive shall be designed to operate from an input voltage of 208/230 +/- 15% VAC or 400/460 +/-15% VAC.
- ii. The AC drive shall operate from an input voltage frequency range from 47.5 to 63 Hz.
- iii. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.
- iv. The efficiency of the AC drive at 100% speed and load shall not be less than 96%.
- v. The constant torque overtorque capacity will be 150% for 1 minute (The variable torque overtorque capacity will be 110% for 1 minute).
- vi. The output switching frequency of the drive will be randomly modulated and selectable at 2 kHz, 4 kHz, 12 kHz or 16 kHz depending on drive rating for low noise operation.
- vii. The output frequency shall be from 0.1 to 500 Hz (selectable at 50 Hz, 60 Hz, 200 Hz, 500 Hz).
- viii. The AC drive will be able to provide rated motor torque at 0.5 Hz in a Sensorless Flux Vector mode using a standard motor and no tachometer feedback.

c. Protection

- i. Upon power-up, the AC drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, (dynamic brake failure), DC to DC power supply, control power, and the pre-charge circuit.

- ii. The AC drive shall be protected against short circuits between output phases; between output phases and ground; on the control terminal outputs; and the internal supplies. The logic and analog outputs shall also be optically isolated.
 - iii. The AC drive shall have a minimum of power loss ride-through of 200 msec. The AC drive shall have the user-defined option of frequency fold-back to increase the duration of the power loss ride-through.
 - iv. The AC drive shall have a selectable ride through function which will allow the logic to maintain control for a minimum of one second without faulting.
 - v. For a fault condition other than ground fault, short circuit or internal fault, an auto restart function will provide restart.
 - vi. The deceleration mode of the AC drive shall be programmable for normal and fault conditions. The stop modes shall include free-wheel stop, fast stop and DC injection braking.
 - vii. A synchronized restart shall be provided that will catch a spinning motor by sensing the motor frequency and rotational direction and synchronize the AC drive's output prior to restarting.
 - viii. Upon loss of the analog process follower reference signal, the AC drive shall fault and/or operate at a user defined speed set between software programmed low speed and high-speed settings.
 - ix. The AC drive shall have solid state protection that is UL listed and meets UL 508C as a Class 20 overload protection and meets IEC 947. The adjustment shall be from 0.45 to 1.05 percent of the current output of the AC drive.
 - x. The AC drive shall have a thermal switch with a user selectable pre-alarm that will provide a minimum of 60 seconds delay before over temperature fault.
- d. Operator Interface
- i. The full English operator interface terminal will offer the modification of AC drive adjustments via a touch keypad. All electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics will be shown.
 - ii. The AC drive keyboard will announce horsepower and voltage.
 - iii. The display shall be capable to be configured to display multiple parameters with numeric data that is selectable and scalable by the operator. A user defined display value proportional to output frequency shall be available. As a minimum the display values shall consist of speed reference, output frequency,

output current, motor torque, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, motor speed and output power.

G. Execution

a. Installation

- i. The installation shall be in compliance with the manufacturer's instructions, drawings and recommendations. The AC drive manufacturer shall provide a factory certified technical representative to supervise the contractor's installation, testing and start-up of the AC drive(s).
- ii. The contractor shall assume the responsibility for coordinating the purchased equipment with the motor served and with the automatic temperature control system, paying specific attention to the signal sent and received, the ground source and the required speed range.
- iii. The manufacturer shall provide start-up of the variable frequency drive and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for VFD field repair are not acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Start-up shall include customer operator training at the time of the equipment commissioning.
- iv. The VFD shall be mounted with operator interface between 4'-6" and 5'-6" above finished floor for visibility and accessibility.

H. Training

- a. An on-site training session of (4) hours duration shall be provided by a representative of the AC drive manufacturer and shall included in the base bid for the project.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0513

SECTION 23 0519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
 - 4. Flowmeters.
 - 5. Thermal-energy meters.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule for thermometers, gages, flowmeters and thermal-energy meters indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer, gage, flowmeter and thermal-energy meter, signed by product manufacturer.
- D. Operation and Maintenance Data: For flowmeters and thermal-energy meters to include operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Case: Die-cast aluminum or brass, 7 inches long.
- B. Tube: Red or blue reading, mercury or organic liquid filled, with magnifying lens.
- C. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- D. Window: Glass or plastic.
- E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- F. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- G. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

- A. Case: Die-cast aluminum, 7 inches long.
- B. Tube: Red or blue reading, mercury or organic filled, with magnifying lens.
- C. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- D. Window: Glass or plastic.
- E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- F. Stem: Metal, for installation in mounting bracket and of length to suit installation.
- G. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.
- H. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 PRESSURE GAGES

- A. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
 - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Red metal.
 - 7. Window: Glass or plastic.
 - 8. Ring: Brass.
 - 9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- B. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.
 - 1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter for panel mounting.
 - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Red metal.
 - 7. Window: Glass or plastic.
 - 8. Ring: Brass.
 - 9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- C. Pressure-Gage Fittings:
 - 1. Valves: NPS 1/4 brass or stainless-steel needle type.
 - 2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.

3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 TEST PLUGS

- A. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- B. Minimum Pressure and Temperature Rating: 300 psig at 250 deg F.
- C. Core Inserts: One or two self-sealing rubber valves.
 1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
 2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.
- D. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.
 2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
 3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
 4. Carrying case shall have formed instrument padding.

2.6 WAFER-ORIFICE FLOWMETERS

- A. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.
- B. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
- C. Pressure Rating: 300 psig.
- D. Temperature Rating: 250 deg F.
- E. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

- F. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 1 percent between 20 and 80 percent of range.
- G. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 2 percent between 20 and 80 percent of range.
- H. Operating Instructions: Include complete instructions with each flowmeter.

2.7 VENTURI FLOWMETERS

- A. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.
- B. Construction: Bronze, brass, or factory-primed steel; with brass fittings and attached tag with flow conversion data.
- C. Pressure Rating: 300 psig.
- D. Temperature Rating: 250 deg F.
- E. End Connections for NPS 2 and Smaller: Threaded.
- F. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
- G. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.
- H. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 1 percent between 20 and 80 percent of range.
- I. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.
 - 1. Scale: Gallons per minute.

2. Accuracy: Plus, or minus 2 percent between 20 and 80 percent of range.

J. Operating Instructions: Include complete instructions with each flowmeter.

2.8 TURBINE FLOWMETERS

A. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.

B. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

C. Pressure Rating: 150 psig minimum.

D. Temperature Rating: 220 deg F. minimum.

E. Display: Visual instantaneous rate of flow.

F. Accuracy: Plus, or minus 2-1/2 percent.

2.9 PITOT-TUBE FLOWMETERS

A. Description: Insertion-type, differential-pressure design for inserting probe into piping and measuring flow directly in gallons per minute.

B. Construction: Stainless-steel probe of length to span inside of pipe; with integral transmitter and direct-reading scale.

C. Pressure Rating: 150 psig minimum.

D. Temperature Rating: 220 deg F. minimum.

E. Display: Visual instantaneous rate of flow.

F. Integral Transformer: For low-voltage power connection.

G. Accuracy: Plus, or minus 1 percent for liquids and gases.

2.10 FLOW INDICATORS

A. Description: Instrument for installation in piping systems for visual verification of flow.

B. Construction: Bronze or stainless-steel body; with sight glass and plastic pelton-wheel indicator and threaded or flanged ends.

- C. Pressure Rating: 150 psig.
- D. Temperature Rating: 220 deg F.
- E. End Connections for NPS 2 and Smaller: Threaded.
- F. End Connections for NPS 2-1/2 and Larger: Flanged.

2.11 INSERTION-TURBINE, THERMAL-ENERGY METER SYSTEMS

- A. Description: Flow sensor, strainer, two temperature sensors, transmitter, meter, and connecting wiring.
- B. Flow Sensor: Insertion-type turbine or paddle-wheel element with corrosion-resistant-metal body and transmitter.
 - 1. Pressure Rating: 150 psig.
 - 2. Temperature Range: 40 to 250 deg F.
- C. Meter: Solid-state integrating type.
 - 1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - 2. Accuracy: Plus, or minus 1 percent.
 - 3. Battery Pack: Five-year lithium battery.
- D. Strainer: Full size of main line piping.

2.12 INLINE-TURBINE, THERMAL-ENERGY METER SYSTEMS

- A. Description: Flow sensor, two temperature sensors, transmitter, meter, and connecting wiring.
- B. Flow Sensor: Turbine-type water meter with corrosion-resistant-metal body and transmitter.
 - 1. Pressure Rating: 150-psig minimum working-pressure rating.
 - 2. Temperature Range: 40 to 250 deg F.
- C. Meter: Solid-state integrating type.
 - 1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - 2. Accuracy: Plus, or minus 1 percent.
 - 3. Battery Pack: Five-year lithium battery.

- D. Strainer: Full size of main line piping.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers as indicated on the drawings and in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Outside-air, return-air, and mixed-air ducts.
- B. Provide the following temperature ranges for thermometers:
 - 1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
 - 2. Chilled Water: 30 to 120 deg F, with 2-degree scale divisions.
 - 3. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

- A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.
- B. Install liquid-filled-case-type pressure gages at chilled water inlets and outlets of chillers.
- C. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
- E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

- F. Install remote-mounting pressure gages on panel.
- G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).
- H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.
- I. Install test plugs in tees in piping.
- J. Install flow indicators, in accessible positions for easy viewing, in piping systems.
- K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
- L. Install flowmeter elements in accessible positions in piping systems.
- M. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.
- N. Install wafer-orifice flowmeter elements between pipe flanges.
- O. Install permanent indicators on walls or brackets in accessible and readable positions.
- P. Install connection fittings for attachment to portable indicators in accessible locations.
- Q. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.
- R. Assemble components and install thermal-energy meters.
- S. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.4 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy-meter transmitters to meters.

3.5 ADJUSTING

- A. Calibrate meters according to manufacturer's written instructions, after installation.

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

END OF SECTION 23 0519

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Pipe stands.
 - 7. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
 - 3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
 - 4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 5. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Fiberglass pipe hangers.
 - 3. Thermal-hanger shield inserts.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Pipe stands. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel.", AWS D1.3, "Structural Welding Code--Sheet Steel.", AWS D1.4, "Structural Welding Code--Reinforcing Steel." and ASME Boiler and Pressure Vessel Code: Section IX.
- B. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.2, "Structural Welding Code--Aluminum."
 - 3. AWS D1.3, "Structural Welding Code--Sheet Steel."
 - 4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - 5. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Material: Carbon Steel
- C. Coating: Galvanized, Hot dipped galvanized
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

2.7 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Base: Plastic.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

- E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 1. Bases: One or more plastic.
 - 2. Vertical Members: Two or more protective-coated-steel channels.
 - 3. Horizontal Member: Protective-coated-steel channel.
 - 4. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified 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 padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 - 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 - 11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 - 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 - 16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 - 17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 - 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
 - 19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary, to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

- a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical type supports and one trapeze member.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel 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 building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- N. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:

- a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood inserts.
 6. Insert Material: Length at least as long as protective shield.
 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 0529

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment (Note: Plastic Labels utilized in a return air plenum shall be listed and approved for use in a return air plenum):
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: White.
 - 3. Background Color: Red.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Red.
- C. Background Color: White.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. (Note: Plastic Labels utilized in a return air plenum shall be listed and approved for use in a return air plenum):
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, and as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link or beaded chain.
- 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.

2.5 CEILING DOT

- A. Provide color coded ceiling dot where HVAC isolation valves & equipment are located above. Conform to owner color standard.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Division 09.

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

3.4 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; and shutoff valves. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Refrigerant: 2 inches, round.
 - 2. Valve-Tag Color:
 - a. Refrigerant: Natural.
 - 3. Letter Color:
 - a. Refrigerant: Black.

3.5 WARNING-TAG INSTALLATION

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

3.6 CEILING DOT INSTALLATION

- A. Locate on ceiling grid below associated valve

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

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 TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. HVAC equipment quantitative-performance settings.
 - 3. Verifying that automatic control devices are functioning properly.
 - 4. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.
- J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.
- K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.
- L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- P. TAB: Testing, adjusting, and balancing.
- Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- R. Test: A procedure to determine quantitative performance of systems or equipment.
- S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Qualification Data: Within 15 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 45 days from Contractor's Notice to Proceed, submit 4 copies of the Contract Documents review report as specified in Part 3.

- C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Sample Report Forms: Submit two sets of sample TAB report forms.
- F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.
- B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. The Contract Documents examination report.
 - c. TAB plan.
 - d. Work schedule and Project-site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
- C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

- F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
- G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 7.2.2 - "Air Balancing."
- H. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

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

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

- B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

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.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
 - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."
- 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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC

Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible, and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 6. Sensors are located to sense only the intended conditions.
 7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at indicated values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to indicated values.
- S. 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.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature-control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
1. Comply with requirements in ASHRAE 62.1-2007, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- 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. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

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 fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

- b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 6. 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 modes 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 static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - 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. 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 terminal 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 terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 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 maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 - 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 3. Measure total system airflow. Adjust to within indicated airflow.
 - 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units 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. Check air outlets for a proportional reduction in airflow 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. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets 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 the 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 systems similar to 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 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. Check air outlets for a proportional reduction in airflow 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 outside airflow. Adjust the fan and balance the return-air ducts and inlets 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 as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.7 PROCEDURES FOR CONDENSING UNITS

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

3.8 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering- and leaving-water temperatures and water flow.
- B. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.10 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

- C. Measure outside-air, wet- and dry-bulb temperatures.

3.11 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.12 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances (code required minimums must meet or exceed rates indicated on plans):
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Minus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: minus 10 to plus 10 percent.
 - 3. Heating-Water Flow Rate: minus 10 to plus 10 percent.
 - 4. Cooling-Water Flow Rate: minus 10 to plus 10 percent.

3.13 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB firm who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- 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 outside, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- F. DOAS Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.

- h. Sheave make, size in inches, and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - j. Number of belts, make, and size.
 - k. Number of filters, type, and size.
- 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
- 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat coil static-pressure differential in inches wg.
 - g. Cooling coil static-pressure differential in inches wg.
 - h. Heating coil static-pressure differential in inches wg.
 - i. Outside airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outside-air damper position.
 - l. Return-air damper position.
 - m. Vortex 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. Outside-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
- 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - g. Number of belts, make, and size.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.

- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature 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.
- J. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 - i. Air-terminal-device effective area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling unit identification.

- b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
- 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- 3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering- and leaving-air temperature in deg F.
- 4. Evaporator Test Reports (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
- 5. Compressor Test Data (Indicated and Actual Values):
 - a. Suction pressure in psig.
 - b. Suction temperature in deg F.
 - c. Discharge pressure in psig.
 - d. Discharge temperature in deg F.
 - e. Oil pressure in psig.
 - f. Oil temperature in deg F.
 - g. Voltage at each connection.
 - h. Amperage for each phase.
 - i. Kilowatt input.
 - j. Crankcase heater kilowatt.
 - k. Chilled-water control set point in deg F.
 - l. Condenser-water control set point in deg F.
 - m. Refrigerant low-pressure-cutoff set point in psig.
 - n. Refrigerant high-pressure-cutoff set point in psig.

6. Refrigerant Test Data (Indicated and Actual Values):
 - a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig.
 - d. Unloader set points in psig.
 - e. Percentage of cylinders unloaded.
 - f. Bearing temperatures in deg F.
 - g. Vane position.
 - h. Low-temperature-cutoff set point in deg F.
- L. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Compressor make.
 - e. Compressor model and serial numbers.
 - f. Refrigerant weight in lb.
 - g. Low ambient temperature cutoff in deg F.
 2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches wg.
 - b. Outlet-duct static pressure in inches wg.
 - c. Entering-air, dry-bulb temperature in deg F.
 - d. Leaving-air, dry-bulb temperature in deg F.
 - e. Condenser entering-water temperature in deg F.
 - f. Condenser leaving-water temperature in deg F.
 - g. Condenser-water temperature differential in deg F.
 - h. Condenser entering-water pressure in feet of head or psig.
 - i. Condenser leaving-water pressure in feet of head or psig.
 - j. Condenser-water pressure differential in feet of head or psig.
 - k. Control settings.
 - l. Unloader set points.
 - m. Low-pressure-cutout set point in psig.
 - n. High-pressure-cutout set point in psig.
 - o. Suction pressure in psig.
 - p. Suction temperature in deg F.
 - q. Condenser refrigerant pressure in psig.
 - r. Condenser refrigerant temperature in deg F.
 - s. Oil pressure in psig.

- t. Oil temperature in deg F.
- u. Voltage at each connection.
- v. Amperage for each phase.
- w. Kilowatt input.
- x. Crankcase heater kilowatt.
- y. Number of fans.
- z. Condenser fan rpm.
- aa. Condenser fan airflow rate in cfm.
- bb. Condenser fan motor make, frame size, rpm, and horsepower.
- cc. Condenser fan motor voltage at each connection.
- dd. Condenser fan motor 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.

3.15 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are 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. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Measure sound levels at two locations.
 - e. Measure space pressure of at least 10 percent of locations.
 - f. Verify that balancing devices are marked with final balance position.
 - g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

- 1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The 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.
4. If the 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."
5. 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.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.16 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 0593

SECTION 23 0700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Insulation Materials:

- a. Calcium silicate.
 - b. Cellular glass.
 - c. Flexible elastomeric.
 - d. Mineral fiber.
 - e. Phenolic.
 - f. Polyisocyanurate.
 - g. Polyolefin.
 - h. Polystyrene.
 - i. Mass loaded vinyl

- 2. Adhesives.
 - 3. Mastics.
 - 4. Lagging adhesives.
 - 5. Sealants.
 - 6. Factory-applied jackets.
 - 7. Field-applied fabric-reinforcing mesh.
 - 8. Field-applied cloths.
 - 9. Field-applied jackets.
 - 10. Tapes.
 - 11. Securements.
 - 12. Corner angles.

- B. Related Sections:

- 1. Division 21 Section "Fire-Suppression Systems Insulation."
 - 2. Division 22 Section "Plumbing Insulation."
 - 3. Division 23 Section "Metal Ducts" for duct liners.

4. Division 33 Section "Underground Hydronic Energy Distribution" for loose-fill pipe insulation in underground piping outside the building.

1.3 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aeroflex
 2. Armacell
 3. Certain Teed Corp.
 4. Johns Manville
 5. Knauf Insulation
 6. Owens Corning
 7. Pittsburg Corning Corp.
- B. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings:
 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail attachment and covering of heat tracing inside insulation.
 3. Detail insulation application at pipe expansion joints for each type of insulation.
 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 6. Detail application of field-applied jackets.
 7. Detail application at linkages of control devices.
 8. Detail field application for each equipment type.
- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

- a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
- b. Sheet Form Insulation Materials: 12 inches square.
- c. Jacket Materials for Pipe: 12 inches long by NPS 2.
- d. Sheet Jacket Materials: 12 inches square.
- e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. Field quality-control reports.

G. Chilled water pump insulation installation instructions.

1.5 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per 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 and inspecting agency.

- 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
- 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Calcium Silicate:

1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Block Insulation: ASTM C 552, Type I.
 2. Special-Shaped Insulation: ASTM C 552, Type III.
 3. Board Insulation: ASTM C 552, Type IV.
 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied FSK jacket. For equipment applications, provide insulation with factory applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. 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. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 2. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- L. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of

insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

- M. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- N. Phenolic:
1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Preformed Pipe Insulation: ASJ.
 - b. Board for Duct and Plenum Applications: ASJ.
 - c. Board for Equipment Applications: ASJ.
- O. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
 2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
 3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Pipe Applications: ASJ-SSL.
 - b. Equipment Applications: ASJ-SSL.
- P. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- Q. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

- R. Mass Loaded Vinyl: Flexible, non-reinforced mass loaded vinyl that resists the passage of sound waves and reduced the transmission of airborne noise. Weight of 1 lb/sq ft; 0.100" thickness, -40 deg F to 180 deg F temperature range. Noise transmission loss (db) shall be included in the submittal per ASTM E-90-97 E413-87.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
 - 1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.
- G. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- H. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 - 2. Service Temperature Range: 0 to 180 deg F.
 - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.4 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F.
4. Color: White.

2.5 SEALANTS

A. Joint Sealants: Cellular-Glass, Phenolic, Polyisocyanurate and Polystyrene Products.

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
- B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
- C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

2.8 FIELD-APPLIED CLOTHS

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

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.

2. Color: Color-code jackets based on system.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union cover.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union cover.

- 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.
- F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
- G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
- H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
 2. Thickness: 11.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches.
 2. Thickness: 6.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Width: 3 inches.
 - 2. Film Thickness: 4 mils.
 - 3. Adhesive Thickness: 1.5 mils.
 - 4. Elongation at Break: 145 percent.
 - 5. Tensile Strength: 55 lbf/inch in width.
- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Width: 3 inches.
 - 2. Film Thickness: 6 mils.
 - 3. Adhesive Thickness: 1.5 mils.
 - 4. Elongation at Break: 145 percent.
 - 5. Tensile Strength: 55 lbf/inch in width.

2.11 SECUREMENTS

- A. Bands:
 - 1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 1/2-inch-wide with wing or closed seal.
 - 2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
 - b. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, nylon sheet, 0.030-inch-thick by 1-1/2 inches in diameter.
 - b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
 - b. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

- a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.12 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment 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.

3.2 PREPARATION

- A. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and 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 o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
 - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. 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.
 5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation end around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
1. Provide 1" foam-core insulation on all chilled water pumps. Install pump insulation per foam-core insulation manufacturer's pump insulation installation instructions. Include pump insulation installation instructions with insulation submittals.
 2. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets,

- valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent

pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Boiler Breechings and Ducts:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.9 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.10 MINERAL-FIBER INSULATION INSTALLATION

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 o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but 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.

E. 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, for 75 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, 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 overcompress 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 1 edge and 1 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 2 times the insulation thickness but not less than 3 inches.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- F. 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, for 75 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress 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 1 edge and 1 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 2 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.

3.11 PHENOLIC INSULATION INSTALLATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.13 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.14 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.15 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 PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. 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.

D. 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.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.16 FINISHES

- A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: Coat exposed outdoor flexible elastomeric insulation with two coats of manufacturer's recommended protective white coating; or cover with aluminum jacketing all exposed outdoor flexible elastomeric insulation, in lieu of paint.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.17 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.18 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply return, and outdoor air.
2. Indoor, exposed outdoor air.
3. Outdoor, concealed supply and return.
4. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Indoor, exposed supply and return air in air conditioned, occupied spaces
4. Exhaust ductwork
5. Factory-insulated flexible ducts.
6. Factory-insulated plenums and casings.
7. Flexible connectors.
8. Vibration-control devices.
9. Factory-insulated access panels and doors.

3.19 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Supply-air Ducts, concealed (installed above ceilings):
 - 1. Mineral-Fiber Blanket: 2 inches thick and installed R-5.0.
- B. Return Air Ducts, Transfer Ducts; Concealed (installed above ceilings):
 - 1. 1" thick flexible elastomeric duct liner (provided with anti-microbial growth coating).
- C. Exposed Supply Ductwork in Air Conditioned, Occupied Spaces:
 - 1. Wrap the first 10'-0" of exposed supply, return or exhaust ductwork in occupied areas with a mass loaded vinyl noise barrier or as noted on plans.
 - 2. Mineral-Fiber Blanket: 1 inch thick and installed R-3.
 - a. Jacket shall be paintable in the field
- D. Exposed Supply and Return Ductwork exposed in Air-Conditioned Utility Spaces (Conditioned Mechanical Rooms or Mechanical Rooms used as Return Air Plenums) and Exposed in Non-Air-Conditioned Spaces (Boiler Rooms, et. Al):
 - 1. Mineral-Fiber Board Insulation: 2 inches thick and installed R-5.0.
- E. Outside-Air Ducts:
 - 1. Mineral-Fiber Blanket: 2 inches thick and installed R-5.0.

3.20 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Supply-air, return-air and outside-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches and 3-lb/cu. ft. nominal density.
 - 2. Mineral-Fiber Board: 3 inches thick and 3-lb/cu. ft. nominal density.

3.21 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

3.22 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.23 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate, and Equipment Drain Water:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 3/4 inch thick.
 - c. Polyisocyanurate: 1 inch thick.
- B. Refrigerant Suction and Hot-Gas Piping:
 - 1. Insulation shall be installed per the manufacturer's recommendations.

3.24 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping:
 - 1. All Pipe Sizes: Insulation shall be as recommended by the manufacturer.

3.25 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.

- C. Ducts, Plenums, and Piping, concealed (installed above ceilings) and Exposed in Air-Conditioned Occupied Spaces:
 - 1. None.
- D. Ducts, Plenums, and Piping, Exposed in Air-Conditioned Utility Spaces (Conditioned Mechanical Rooms and Mechanical Rooms used as Return Air Plenums):
 - 1. 8-ounce canvas with lagging adhesive.
- E. Ducts, Plenums, and Piping, Exposed in Non-Air-Conditioned Spaces (Boiler Rooms, et. al.):
 - 1. PVC: 20 mils thick (N/A if installed in a return air plenum).
 - 2. Aluminum, Smooth: 0.016 inch thick.
- F. Equipment, concealed (installed above ceilings):
 - 1. None.
- G. Equipment, Exposed (all applications):
 - 1. PVC: 20 mils thick (N/A if installed in a return air plenum)
 - 2. Aluminum, Smooth: 0.016 inch thick.

3.26 OUTDOOR, 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. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. PVC: 20 mils thick.
 - 2. Aluminum, Smooth: 0.016 inch thick.
- D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 - 1. Aluminum, Smooth: 0.016 inch thick.
- E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
 - 1. Aluminum, Smooth with 0.032 inch thick.
- F. Equipment, Concealed:

1. None.

G. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Painted Aluminum, Smooth: 0.016 inch thick.

H. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, Smooth with 0.032 inch thick.

I. Piping, Concealed:

1. None.

J. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.
2. Aluminum, Smooth: 0.016 inch thick.

3.27 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 0700

SECTION 23 08 00 – COMMISSIONING - MECHANICAL

PART 1 - GENERAL

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, system calibration, testing adjusting and balancing, performance testing and training.

MEP commissioning for this project shall be provided to fulfill the requirements of Section C408 of the North Carolina Energy Conservation Code and NC General Statute 143-135.35-.40 (SB 668). The process structure is based on ASHRAE Guideline 0-2013, ASHRAE Guideline 1.1-2007, ASHRAE Guideline 202-2013 and practices by the NEBB Commissioning Standard.

- A. Review the Owner's Project Requirements (OPR) and design team's Basis of Design (BOD) for clarity and completeness.
- B. Develop commissioning requirements to be included in the construction documents.
- C. Perform a commissioning design review of the design documents and back-check the review comments prior to submission.
- D. Develop and implement the commissioning plan.
- E. Review contractor submittals applicable to systems being commissioned for compliance with the OPR, OBD and design documents.
- F. Verify applicable equipment and systems are installed properly and receive adequate operational checkout by installing contractors.
- G. Verify and document proper performance of plumbing systems.
- H. Assist in review of O&M manuals and warranties.
- I. Develop a Systems Manual to provide future operating staff the information needed to understand and optimally operate the commissioned systems.
- J. Coordinate and verify that the Owner's operating personnel are adequately trained.
- K. Provide a summary of the commissioning activities and submit a commissioning report.
- L. Perform seasonal testing and a review of commissioned systems within the first 10-months after substantial completion.

ABBREVIATIONS

The following are common abbreviations used in the Specifications.

Cx	Commissioning
CxA	Commissioning Authority
PM	Project Manager (Owner)
A/E	Architect and Design Engineers
GC	General / Prime Contractor
EC	Electrical Contractor
PC	Plumbing Contractor
MC	Mechanical Contractor
CC	Controls Contractor
Subs	Subcontractors to General
TAB	Test and Balance Contractor
PFC	Prefunctional Checklist
FPT	Function Performance Test
Cx Plan	Commissioning Plan Document

RELATED SECTIONS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01, 22, 23 and 26 Specification Sections, apply to this section.

COMMISSIONING TEAM

- A. The members of the commissioning team consist of the Commissioning authority (CxA), the Owner Project Manager (PM), the General / prime contractor (GC), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Plumbing Contractor (PC), the Test and Balance Contractor (TAB), the Controls Contractor (CC), any other installing Subcontractors or suppliers of equipment. Additionally, if desires, the facility plant operator/engineer is also a member of the commissioning team. Representative from the A/E team may also be invited to observe critical procedures.
- B. The Contractor shall, through the GC provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Agent in demonstrating prefunctional and functional tests as they relate to each system and their technical specialty.
- C. The Commissioning Agent reserves the right to approve the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include knowledge relative to the specific equipment involved, adequate documentation, tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Agent to get the job done.

MANAGEMENT

- A. The CxA directs and coordinates the commissioning activities and the reports to the Owner. All members work together to fulfill their responsibilities and fulfill the objectives of the Contract Documents.

SCHEDULING

- A. The CxA will work with the GC to project an initial commissioning schedule. The GC will integrate the tentative commissioning schedule into the master schedule. All parties shall address scheduling problems and make necessary notification in a timely manner to avoid delaying the commissioning process. The GC will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.
- B. Functional testing will not begin until the CxA is notified in writing, by the GC that all prefunctional checklists, including startup and TAB work have been completed; and the subcontractors punch work is complete and the systems have been tested completely.
- C. The CxA will have 7 business days to review prefunctional documentation for completeness. If it is determined that the prefunctional and TAB report has not been completed and it impacts the original schedule coordinated by the CxA and GC; the schedule will be revised to include the additional days taken for the contractor to properly complete their work and the CxA to review the document.
- D. As construction progresses, more detailed schedules will be developed by the CxA and GC.
- E. Commissioning is required to be scheduled and completed prior to Substantial Completion.

COMMISSIONING PROCESS DURING CONSTRUCTION

The following narrative provides a brief overview of the commissioning tasks during construction and the general order in which they occur:

- A. Commissioning begins with a Cx kickoff meeting conducted by the CxA where the commissioning process, including Cx Plan is reviewed with the commissioning team members.
- B. Additional meetings will be required throughout construction, scheduled by the PM, CxA & GC with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
- C. Energy related equipment documentation is submitted to the CxA during the normal submittal process for review, after approval by the A/E, including start-up procedures.

- D. The CxA works with the Subs to detail start-up procedures, including providing the Subs with prefunctional checklists (PFC's) to be completed during the startup process.
- E. The TAB contractor submits their TAB plan, for approval by the CxA prior to starting TAB work.
- F. The CxA will review reports from independent testing agencies and A/E reports from on-site periodic construction observation to maintain cohesiveness with project activities.
- G. The CxA will perform site visits and document the progress of the work. An Issues / Deficiency log will be developed to track installation and coordination issues which would affect commissioning and Owner maintenance.
- H. The Subs, under their own direction, execute and document the prefunctional checklists (PFC's), including start-up and initial checkout. The CxA documents that the checklists and start-ups were completed by the Subs according to the approved plans. This will include the CxA witnessing start-up of selected (major) equipment.
- I. The CxA develops specific equipment and system functional performance test (FPT) procedures. The procedures are developed using approved shop drawings and O&M documentation supplied by the contractors.
- J. Under direction of the CxA, functional performance tests (FPT's) are executed by the appropriate sub-contractors. The results of the FPT's are documented by the CxA.
- K. With support from the TAB and CC contractors, the CxA will verify the values reported in the final TAB report.
- L. During prefunctional checkout and functional performance testing, items of non-compliance in material, installation or setup shall be corrected at the Sub's expense and the system retested.
- M. The CxA reviews the O&M documentation for completeness.
- N. The CxA coordinates and verifies training of Owner staff by vendors and sub-contractors.
- O. Deferred / seasonal / warranty testing is conducted with assistance by the appropriate Sub-contractors.

SUBMITTALS

The GC will provide the CxA a copy of the following items, for the systems to be commissioned:

- A. Construction Schedule (initial and all updates)
- B. Construction Progress Meeting Minutes (all meetings)

- C. Approved shop drawings, materials certifications and systems data for energy related systems. Approval review comments by the A/E and any resubmittal required by the A/E shall be copied to the CxA.
- D. One set of approved coordination drawings either electronic media or hard copy which includes all commissioned systems e.g. mechanical, electrical and plumbing.
- E. Piping – Plumbing contractor shall supply one copy of the piping systems pressure test results and one copy of the flushing and clean out report.
- F. Chlorination Report - Plumbing contractor shall supply one copy of the domestic water chlorination report approved by the authority having jurisdiction.
- G. Subs shall submit start-up and initial checkout plan for each piece of equipment / system as recommended by the manufacturer.
- H. Prefunctional checklist (Engineering Point-to-Point Checklist) for controls and energy related equipment as required by this specification.
- I. Operational and maintenance documentation for FPT development.

SYSTEMS TO BE COMMISSIONED

- a. HVAC equipment and service-heating control systems
- b. Control devices and components
- c. Control point trending
- d. Control graphics
- e. Test and balance verification

PART 2 - PRODUCTS

TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested.
- B. All testing equipment used by the contractors shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.

PART 3 - EXECUTION

The following procedures apply to all equipment to be commissioned. This work is to be performed by the contractor or sub-contractor prior to Functional Performance Testing by the Commissioning Team.

GENERAL

- A. Cooperate with the Commissioning Authority in the following manner:
 - 1. Provide and install balancing cocks, access doors, test ports and P&T ports as required by the CxA, A/E and the Owner for functional testing.
 - 2. Allow sufficient time before final completion dates so that functional testing can be accomplished.
 - 3. Provide labor and material to make corrections when required without undue delay.

MEETINGS

- A. Prior to the start of MEP construction, the A/E, PM, CxA, and GC shall schedule, plan and conduct a commissioning kickoff meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CxA.
- B. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular subs.

START-UP AND INITIAL CHECKOUT

- A. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- B. The CxA will develop prefunctional checklists with the Contractor which indicates the required procedures to be executed as part of startup and initial checkout of the systems. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form.
- C. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections

of each procedure and a summary statement with a signature block at the end of the plan.

- D. The full start-up plan shall consist of:
 - 1. The CxA's prefunctional checklists.
 - 2. The manufacturer's standard written start-up procedures copied from the installation manuals with contractor sign-off.

SENSOR AND ACTUATOR CHECKOUT AND CALIBRATION

- A. All field-installed instrumentation sensors and gages shall be calibrated. All test instruments shall have had a certified calibration within the last 12 months.
- B. Calibrate each instrumentation device by making a comparison between the display and the reading at the device, using an instrument traceable to the National Institute of Standards and Technology, which shall be at least twice as accurate as the device to be calibrated, (e.g., if field device is +/- 0.5% accurate, test equipment shall be +/- 0.25% accurate over same range). Record the measured value and displayed value for each device in the prefunctional checklist.

DDC CONTROL SYSTEM

- A. Check each physical output control point by making a comparison between the control command at the DDC system and the status of the controlled device. Check each physical output control point by making a comparison of the actual state of the device and the operator workstation graphical representation of the point condition. Record the results for each device in the Prefunctional checklist.
- B. Verify proper sequences by using the approved checklists to record results and submit the Pre-functional checklist. Verify proper sequence and operation of all specified functions.

EXECUTION OF PREFUNCTIONAL CHECKLISTS AND STARTUP

- A. Thirty (30) days prior to startup, the Subs and vendors schedule startup and checkout with the PM, GC and CxA. The execution of prefunctional checklists, startup and checkout is by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
 - 1. The Subs and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists, plus the final TAB report for all equipment and systems.

2. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off.

DEFICIENCIES, NON-CONFORMANCE AND APPROVAL IN CHECKLISTS AND STARTUP

- A. The Subs (including the TAB contractor) shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the CxA within 1-week of test completion.
- B. The CxA reviews the report and submits either a non-compliance report or an approval form to the PM. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.
- C. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Agent will notify the Architect/Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities.
- D. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

FUNCTIONAL PERFORMANCE TESTING

OBJECTIVES AND SCOPE

- A. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- B. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, failures, interlocks, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power

failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

- C. Demonstrate the operation of the DDC hardware, software, and all related components and systems to the satisfaction of the Commissioning Authority. Schedule the demonstration with the CxA one month in advance. Demonstration shall not be scheduled until submittals, control hardware and software, TAB Final Report, and the Prefunctional checklists are complete and approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of the additional site visits by the Commissioning Authority for re-demonstration, the Contractor shall reimburse Owner for costs of subsequent CxA site visits.
- D. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All documentation, including as-built drawings, O&Ms, and submittals shall be at the job site before functional testing commences.

DEVELOPMENT OF TEST PROCEDURES

- A. The CxA will develop specific functional checklists test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA will provide a copy of the test procedures in advance to the Sub(s) who shall complete the tests.
- B. The Sub(s) shall review and point out to the CxA any specific problems related to the functional checklists because of feasibility, safety, equipment and warranty protection.

COORDINATION AND SCHEDULING

- A. The GC shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems.
- B. Functional testing is conducted after prefunctional and startup testing has been satisfactorily completed and non-compliance form items have been closed out. The air balancing and water balancing must be completed and debugged before CxA completes a TAB checkout of air-related or water-related equipment or systems.
- C. The CxA will schedule functional tests after written notification from the GC and affected Subs. The CxA shall direct, witness and document the functional testing of equipment and systems with support from the Subs.
- D. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

DOCUMENTATION

- A. The CxA shall witness and document the results of all functional performance tests using the specific functional checklist forms developed for that purpose. Prior to testing, these forms are provided to the GC & Subs for review.

NON-CONFORMANCE

- A. The CxA will record the results of the functional test and TAB checkout on a standard Test Form. All deficiencies or non-conformance issues will be noted and reported to the PM on a standard Issues Log.
- B. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the Test Form.
- C. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the PM.
- D. The CxA documents deficiencies and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the Issues Log report to the Sub(s), GC and/or PM. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
- E. The CxA reschedules the test and the test is repeated.
- F. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1. The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the PM, the GC and to the Sub representative assumed to be responsible.
 - 2. Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.
 - 3. The CxA documents the resolution process.
 - 4. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA & GC reschedules the test and the test is repeated until satisfactory performance is achieved.

COST OF RETESTING

- A. The contractor and Subcontractors will notify the CxA that the systems are ready for testing. As such, for a given system it assumed that all specified prefunctional tasks are complete by the contractor or Sub.
- B. If the CxA discovers that the systems are incomplete at the time of the first functional test, the entire system will be marked as deficient and the retesting procedure for deficient systems will be followed.
- C. Deficiencies will be noted by the CxA and documented. Deficiencies are associated with completed systems. For deficiencies not related to any prefunctional checklist or start-up fault, the following shall apply:
 - i. The CxA will conduct retesting (back-check) of the equipment / system once at no charge to the GC for their time.
 - ii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting beyond the initial retesting noted above will be chargeable to the GC.
 - iii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting for items which are a repeated deficiency, previously reported via commissioning deficiency log will be chargeable to the GC.
 - iv. The Contractor shall respond in writing to the CxA and PM at least as often as non-compliance reports (Cx Issues Log) are issued. The response shall report the status of each apparent outstanding discrepancy identified during commissioning. Responses shall cover explanations of any disagreements and proposals for their resolution.
 - v. The CxA retains the original non-conformance form (Cx Issues Log) until the end of the project.
 - vi. The GC shall not consider any required retesting by any Contractor a justified reason for a claim of delay or for a time extension.

APPROVAL

- A. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA, if necessary. The CxA recommends acceptance of each test to the PM using a standard form. The PM gives final approval on each test using the same form, providing a signed copy to the CxA and the Contractor.

OPERATION AND MAINTENANCE MANUALS (O&M'S)

- A. The contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned sixty (60) days in advance of functional testing.
- B. Operation and Maintenance manuals shall conform to requirements detailed in Specification 01 78 00.

OWNER TRAINING

- A. The GC shall be responsible for training coordination, agendas, scheduling and ultimately for ensuring that training is complete per Specification 01 79 00.
- B. The CxA shall be responsible for overseeing and approving the adequacy of the training of Owner personnel for commissioned equipment.
- C. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors are specified in Division 01, 22, 23 and 26.
- D. Each Sub and vendor responsible for training shall submit a written training plan (agenda) to the CxA for review and approval prior to training. The plan shall include the following elements:
 - 1. Equipment (included in training)
 - 2. Intended audience
 - 3. Location of training
 - 4. Objectives
 - 5. Subjects covered (description, duration of discussion, special methods, etc.)
 - 6. Duration of training on each subject
 - 7. Instructor for each subject
 - 8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
- E. The CxA will verify the training was satisfactorily completed and recommend approval of the training to the PM.

WARRANTY AND DEFERRED TESTS

- A. Warranty system testing (10 months after project acceptance) will be conducted and require assistance from the appropriate sub-contractors. Each sub will meet with facility staff to discuss the current building operation and the condition of outstanding issues related to the original commissioning. Problems or concerns they have with operating the building as originally intended will be reviewed, tested and action developed.
- B. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing

may be delayed upon approval of the PM, A/E, and CxA. These tests will be conducted in the same manner as the seasonal tests as soon as possible.

SEASONAL TESTING

- A. During the warranty period, seasonal testing shall be completed as part of this contract. Seasonal testing is intended to test the performance of systems under full load conditions that cannot be simulated during the functional testing period. For example, it is impossible to test the heating system under full load conditions in July, so the heating system would be full load tested during the winter months. The CxA shall coordinate this activity. Tests will be executed, documented, and deficiencies corrected by the appropriate Subs, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the GC.

END OF COMMISSIONING SPECIFICATION SECTION

SECTION 23 0900 - BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Direct Digital Controls (DDC) – BACnet compliant
- B. Programming and Graphics
- C. Controllers (Global, Standalone, Application Specific)
- D. Communications
- E. Sensors
- F. Valves, Dampers and actuators
- G. Electrical appurtenances and wiring systems
- H. Sequence of Operation

1.02 RELATED WORK

- A. Section 23 - Mechanical General Requirements
- B. Division 26 - Electrical

1.03 SHOP DRAWINGS

- A. System Architecture (BACnet LAN scheme)
- B. Wiring diagrams
- C. Valves and actuators
- D. Dampers and actuators
- E. System schematics for all mechanical systems
- F. Material lists with part numbers and quantities, as appropriate
- G. Technical/Product data sheets for each piece of equipment
- H. Sequence of Operation for each system
- I. As-built drawings of installed system

1.04 SUBMITTALS

- A. Submit Shop Drawings of the complete Building Automation System (DDC System) for review and approval.
- B. Drawings shall be submitted on standard sheet size format (8-1/2" x 11", 11" x 17", or 24" x 36").
- C. Drawings shall be bound within a standard 3-ring binder, cover, or other suitable permanent binder. For projects in which the controls submittals will be less than one-half inch thick, the submittal documents may be securely stapled in the upper left-hand corner provided the cover sheet and back sheet are printed on card stock (heavy bond paper).
- D. Submit *five* (5) copies of submittal drawings for review by the Owner.
- E. At completion, furnish as-built drawings in bound form and on CD.

- F. Submit documentation for all DDC programming in graphical form (AutoCAD or Visio format, or equal) as a part of the as-built documentation.
- G. Submit manufacturer's operating instruction manual for the DDC control system for use in owner training.
- H. Submit Certificate of Training upon completion of all scheduled training of the owner's operating personnel.

1.05 CODES AND REFERENCE STANDARDS

The latest edition of the following standards and codes in effect and amended as of the date of the supplier's proposal, and any subsections thereof as applicable, shall govern the design and selection of equipment and material supplied.

- A. NFPA 70 - National Electrical Code (NEC)
- B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers (Handbooks)
- C. ANSI/ASHRAE Standard 135 (1995) – BACnet: A Data Communication Protocol for Building Automation and Control Networks
- D. UL 916 - Standard for Energy Management Equipment
- E. FCC – Part 15, Subpart J
- F. City, County, State and Federal regulations and codes in effect as of the date of the Contract

- 1.06 PERMITS Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for all necessary approvals by the governing authorities.

1.07 QUALITY ASSURANCE

- A. Responsibility: The supplier of the HVAC digital logic control system shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.
- B. Component Testing: Maximum reliability shall be achieved through extensive use of high quality, pre-tested components. The manufacturer prior to shipment shall individually test each and every controller, sensor, and all other DDC components.
- C. Tools, Testing and Calibration Equipment: The control system supplier shall provide all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the control system.
- D. Authorized Representative: The systems control contractor shall have been in business a minimum of three years and be the authorized representative for the manufacturer of the BACnet components.

1.08 WARRANTY

The DDC control system installed under this Specification shall be free from defects in material and workmanship under normal use and service for a period of twelve (12) months after final acceptance by the Owner. If within the twelve (12) month warranty period, any equipment, software, or labor is found to be defective in workmanship or materials, it shall be replaced free

of charge by the Controls system installer. Warranty service shall be available to the job site during normal working hours.

1.09 PREVENTATIVE MAINTENANCE

The DDC control system installed as part of this project shall include a preventative maintenance schedule including two four-hour inspections per building twice within the first year of operation. The college desires one service company to have responsibility for maintaining the entire campus-wide automation system. Therefore, the successful bidder shall be responsible for conducting similar inspections at all campus buildings with DDC controls.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Installation of the system shall be by qualified employees of the temperature control system manufacturer or its exclusive authorized representative and qualified subcontractor. Indirect temperature control work by non-qualified installing contractors performing work without direct supervision from the authorized representative will not be accepted.
- B. The installing contractor shall provide all tools, testing and calibration equipment necessary to ensure reliability and accuracy of the control system.

2.02 SYSTEM REQUIREMENTS

- A. Requirement:
ALL POINTS SHALL HAVE FULL RANGE MANUAL OVERRIDES, SYSTEM SAFETIES Owner SHALL HAVE PRIORITY OVER MANUAL OVERRIDE.
- B. Furnish a totally native BACnet-based system for distributed logic control in accordance with this specification. The system operator's terminal, all global controllers, and all input/output devices shall communicate using the protocols and local area network (LAN) standards as defined by ANSI/ASHRAE Standard 135 – 1995 (BACnet). No gateways shall be used.
- C. The proposed system must be completely compatible with the owner's existing web based Tridium DDC control system. The controls contractor shall include in his proposal any and all hardware, software, engineering or graphics development required to integrate the new control system into the existing graphical user interface. If a separate front-end computer is required then the contractor is also required to provide the necessary hardware, programming, and software to communicate to all the owner's existing buildings and provide graphic displays for the new building and all equipment currently controlled by the Tridium system.
- D. The system shall be a complete system of automatic temperature controls of the Direct Digital Control (DDC) type with electric and electronic accessories and components as indicated and as required.
- E. All control items, except thermostats, sensors and transmitters located in rooms shall be properly identified with engraved plastic nameplates permanently attached. Nameplates shall have white letters on a black background.

- F. Room thermostat, sensor and transmitter locations shall be coordinated to align vertically or horizontally with adjacent light switches or other control devices. Room thermostats and sensors shall be mounted with the bottom 5'-0" above the floor.
- G. Owner's Representative shall furnish disk file copies of the building floor plan(s) in AutoCAD (or other compatible drafting package format) for use by the DDC system Contractor in creating custom system graphics for displays.

2.03 SENSORS, TRANSMITTERS AND THERMOSTATS

- A. Temperature Sensors: Thermistor type with an accuracy of plus or minus 0.40-degree F over the entire control range. Sensors for pipe installations shall be immersion type, brass well, and thermistor with integral lead wire. Sensors for duct application shall be insertion probe type, stainless steel probe, integral handibox, and thermistor with integral lead wire. Space temperature sensors shall be compatible with the unit controller and shall be provided in a decorative metal or plastic enclosure. Space temperature sensors shall be provided with setpoint adjustment (lever or slide type), and override pushbutton, and connection port for field service tool. Outdoor temperature sensors shall be mounted inside a protective weather and sun shield.
- B. Space Temperature Sensor: Wall mounted room sensor, no occupant controls. The controller shall also be capable of functioning as a field service tool to allow maintenance personnel to observe and adjust all control parameters resident in the terminal unit controller. These control parameters shall also be adjustable from the global controller. Sensor shall be standard two-wire connection and have a thermistor, housed in a decorative plastic enclosure.
- C. Humidity Sensors: Thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140-degree F. Duct mounted type sensors shall have a stainless-steel insertion element, sealed to prohibit corrosion. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.
- D. Current Switches (Type 1): For proving fan or pump operational status, provide split-core type current status switches with adjustable setpoint and solid-state internal circuitry. Current switch shall have induced power, trip point set adjustment to plus or minus 1% over a range of 1 to 135 amps, trip and power LED, and field adjustable to indicate both On-Off conditions and loss of load (broken belt, etc.). Units shall have a five-year manufacturer's warranty. Current switches shall be Hawkeye Series H-908 by Veris Industries or approved equal.
- E. Low Temperature Sensors: For sensing low temperatures in air handling units, provide SPST type switch, 35 to 45-degree F range, manual reset, vapor charged twenty-foot-long sensing element, and 120-volt electrical power connection.

2.04 MISCELLANEOUS MATERIALS

- A. Panels: All enclosures for DDC controllers and devices shall be fabricated in accordance with UL Standards from code gauge steel. Enclosures shall be provided with a continuous hinge on the door and a flush latching mechanism. Enclosures shall be shop painted with standard grade enamel coating. Back panels shall be furnished when required to facilitate installation of boards or accessories. All enclosures installed outdoors shall be constructed to NEMA 3R

standards. All controllers shall be installed within an approved enclosure unless the controller will be installed within the control cabinet section of the equipment that it is intended to control. Enclosures shall facilitate the mounting of gauges, switches, pilot lights, and the like, on the face panel when required. Control devices that are mounted on the face of the panel shall be identified with engraved nameplates.

- B. Power Transformers: Step-down power transformers shall be provided for all DDC controllers and associated accessory devices as required. Transformers shall be sized and selected to accommodate all connected accessory items. Transformers shall be UL Listed Class 2 type with 120 VAC primary, 24 VAC secondary.
- C. Relays: Miscellaneous control relays shall be provided as required to energize or control equipment and devices within the control system. Relays shall be located as close as practical to the controlled device (motor, motor starter, etc.). Where approved by NEC, relays may be installed within starters and equipment control panels where space is available. Relays installed outside of the controlled device shall be provided with a NEMA enclosure suitable for the location where installed.
- D. Wiring: All wiring shall be installed in a neat and professional manner. Control wiring shall not be installed in power circuit conduits or raceways unless specifically approved for that purpose. All wiring shall be plenum rated cable where concealed and in EMT conduits when exposed.
 - 1. Provide all interlock and control wiring. Provide wiring as required by functions as specified and as recommended by equipment and device manufacturers to achieve the specified control functions.
 - 2. Low voltage conductors shall be stranded bare or tinned copper with premium grade polymer alloy insulation. For shielded cable, furnish multi-conductor of overall polyester supported aluminum foil with stranded tinned copper drain wire to facilitate grounding. Coaxial shield shall be copper braided type. Provide shielded cable where recommended by the equipment or device manufacturer, grounded in strict accordance with the manufacturer's recommendations.
 - 3. Low voltage wiring shall be UL Listed type for the intended application. Non-plenum type cable shall be UL Type CM and /or CMR. Plenum type cable shall be UL type CMP and /or CL3P for approved plenum installations.

DIRECT DIGITAL CONTROL SYSTEM

- 2.05 GENERAL: The Direct Digital Control (DDC) System shall consist of native BACnet type global controller(s) and standalone or application specific unitary controller(s) configured as a distributed communications network composed of one or more levels of BACnet compliant local area networks (LAN). No gateways shall be used except when required to interface with specific equipment furnished by another manufacturer (e.g.: chiller controllers, packaged equipment controllers, etc.). The intent of the distributed control strategy is to install the controllers in close proximity to the equipment being controlled, and to distribute the processing to each standalone DDC panel. In the event of a communications failure of the BACnet LAN, the controllers shall be capable of operating in standalone mode. All devices (global controllers, standalone controllers, programmable controllers, etc.) shall be UL Listed, FCC approved, and BACnet compliant.

2.08 WORK INCLUDED

- A. Furnish a totally native BACnet-based system based on distributed logic control in accordance with this specification section. The existing operator's terminal, all global controllers, logic controllers, and all input/output devices shall communicate using the protocols and local area network (LAN) standards as defined by ANSI/ASHRAE Standard 135-1995, BACnet. All DDC controllers, including unitary controllers, shall be native BACnet devices. In general, no gateways shall be used except when required to interface with specific equipment furnished by another manufacturer. Scope of work will include, but not be limited to, the following:
1. Provide all necessary BACnet compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for every controller in the system, including unitary controllers. All direct digital logic hardware is to comply with BACnet.
 2. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
 3. Implement the detailed design for all system-standard analog and binary objects, distributed control and system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
 4. Design, provide, and install all equipment enclosures, panels, data communication network cables needed, and all associated hardware.
 5. Provide and install all interconnecting cables between supplied enclosures, logic controllers, and input/output devices.
 6. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this contract.
 7. Provide complete manufacturer's product data for all items that are supplied. Include vendor name of every item supplied.
 8. Provide qualified supervisory personnel and technicians at the job site to assist in all phases of system installation, startup, and commissioning.
 9. Provide for operator training as described in this Section.
 10. Provide "as-built" documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
 11. Provide new dampers, valves, actuators, sensors, controllers, and the like. No used components shall be provided as any part or piece of the installed system.

2.09 SYSTEM DESCRIPTION

A. General Requirements

1. The existing graphical user interface provides web access for monitoring, controlling, scheduling, and alarm notification for all buildings connected to the system. The CAS utilizes the campus WAN to interconnect all of the buildings to the network server. At the conclusion of this project, the new building system will be added to the existing server software and will provide the same functionality and look as the existing system.

2. A distributed logic control system completes with Direct Digital Control (DDC) and Direct Analog Control (DAC) software shall be provided. System shall be totally based on ANSI/ASHRAE Standard 135 – 1995, BACnet. This system is to control all mechanical equipment, including all unitary equipment such as packaged air conditioning units, and all air handling units, boilers, chillers, and any other listed equipment on this project using native BACnet-compliant components.
3. The entire processing system shall be in complete compliance with the BACnet standard. The system shall use BACnet protocols and LAN types throughout and exclusively. Non-BACnet compliant or proprietary equipment or systems (including gateways, except as specified previously) shall *not* be acceptable and are specifically prohibited.
4. All logic controllers for terminal units, air handlers, central mechanical equipment, and Microsoft Windows-based operator's terminal(s) shall communicate and share data, utilizing only BACnet communication protocols.
5. All logic controllers shall be fully programmable. Programmable controllers for every terminal unit, air handler, all central plant equipment, and any other piece of controlled equipment shall be provided. Programming tools shall be provided as part of the operator workstation for every controller supplied for the project.
6. The Controls Contractor shall assume complete responsibility for the entire controls system as a single source. He shall certify that he has factory-trained personnel on staff under his direct employ on a daily basis. These employees shall be qualified to engineer, program, debug, and service all portions of the BACnet based logic control system. This shall include operator's terminal, global controllers, routers, programmable controllers, terminal unit controllers, sensors and all other components of the system.

B. Basic System Features

1. Zone-by-zone direct digital logic control of space temperature, scheduling, optimum start, equipment alarm reporting, and override timers for after-hours usage. A zone is the area served by one HVAC logic controller unit, VAV box, or multi-zone unit.
2. Operator's terminal software shall be Microsoft Windows 7 based. The Building Automation System application program shall be written to communicate specifically utilizing BACnet protocols. Software shall be multi-tasking, capable of executing and displaying multiple instances in individual windows while running concurrently with other Windows programs such as word processors or database programs. Software shall support Windows Dynamic Data Exchange (DDE) interfaces. Software shall strictly follow Microsoft Windows API guidelines. Systems using proprietary software or operating systems other than that described above are strictly prohibited. Operation of the terminal software shall be simple and intuitive.
3. Operator's terminal software shall contain an easy-to-operate system allowing configuration of system-wide BACnet controllers, including management and display of the controller programming. This system shall provide the capability to configure controller binary and analog inputs and outputs.
4. Operator's terminal operating system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages. Graphics generation shall be done using

standard Windows packages. No proprietary graphics generation software shall be required.

5. When specified, at least one operator's terminal shall be equipped to act as a system server. This system server shall store custom copies of loadable software for all field components and shall be capable of automatic or manual reloading of such software into the field components as required. The system server shall also gather and archive system operating data, such as trendlogs, energy logs, and other historical operating data.
6. Complete energy management firmware, including self-adjusting optimum start, demand limiting, global control strategies and logging routines for use with total control systems shall be supplied. All energy management firmware shall be resident in field hardware and shall not be dependent on the operator's terminal for operation. Operator's terminal software is to be used for access to field-based energy management control firmware only.
7. Priority password security systems shall prevent unauthorized use. Each user shall have an individual password. The user shall only be given access to the system functions required for individual job performance.
8. Equipment monitoring and alarm functions, including information for diagnosing equipment problems shall be included with the system.
9. The complete system, including, but not limited to terminal unit controllers, global controllers and operator's terminals shall auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in global controller memory shall be battery-backed up for a minimum of one (1) year. Logic controllers for all air handlers and all unitary equipment shall utilize EEPROM for all variable data storage. Batteries on unitary controllers shall not be allowed.
10. System design shall be modular and have proven reliability.
11. All software and /or firmware interface equipment for connection to remote monitoring station from field hardware or the operator's terminal shall be provided.
12. System shall be capable of equipment runtime totalization of fans, heaters, boilers, pumps and the like and capable of alarm generation and alarm dial-out to remote sites.
13. Communication wiring from field controllers shall NOT be run in star patterns.
14. All controllers shall communicate using protocols and LAN types contained in the ANSI/ASHRAE Standard 135 – 1995, BACnet.
15. All DDC hardware and software shall be designed and manufactured by U.S. corporations. All hardware shall be Listed Underwriters Laboratories (UL) for Open Energy management Equipment (PAZX) under the UL Standard for Safety (UL 916) in both the U.S. and Canada, with integral labels showing the rating.
16. All hardware shall be in compliance with FCC Part 15, Subpart J, Class A.

2.10 OPERATOR'S TERMINAL

A. Operating System

1. The GUI shall run on latest Microsoft Software.
 - a. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the

hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

- b. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
 - i. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
 - ii. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
 - iii. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
 - iv. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
 - v. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - vi. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - vii. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - viii. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
- c. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
 - i. Create, delete or modify control strategies.
 - ii. Add/delete objects to the system.
 - iii. Tune control loops through the adjustment of control loop parameters.
 - iv. Enable or disable control strategies.
 - v. Generate hard copy records or control strategies on a printer.
 - vi. Select points to be alarmable and define the alarm state.

- vii. Select points to be trended over a period of time and initiate the recording of values automatically.
- d. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- e. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- f. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
- g. Alarm Console
 - i. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
 - ii. When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2. WEB BROWSER CLIENTS

- a. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ . Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- b. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the DDC system, shall not be acceptable.
- c. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is

provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

- d. The Web browser client shall support at a minimum, the following functions:
 - i. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - ii. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
 - iii. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - iv. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
 - v. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
 - vi. User's shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - vii. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - viii. Commands to start and stop binary objects shall be done by right clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - ix. View logs and charts
 - x. View and acknowledge alarms
 - xi. Setup and execute SQL queries on log and archive information
 - xii. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

- xiii. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

C. Display of Scheduling Object Information

1. Operator's terminal display of weekly schedules shall show all information in convenient 7-day (weekly) format for each schedule. This includes all On/Off times (accurate to the minute) for each day's events.
2. BACnet exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the normal weekly schedules. These specialty schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, with input requirements similar to weekly schedules. Holiday and event schedules shall be entered as either single day entries, date-to-date entries (covering a range of days), or by weekday (for example, a specific day of a given week each month). The operator shall be able to scroll through the months for each year as a minimum.
3. At the Operator's Terminal, the system user shall be capable of changing all information for a given weekly or specialty schedule if logged on with the appropriate security access.

D. Alarm Indication

1. Operator's Terminal shall provide audible, visual and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) being run at the time (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.
2. Alarm messages shall be logged. Alarm log shall be archived to the hard disk of the system terminal. Each entry shall include a description of the event which generated the alarm, time and date of alarm occurrence, time and date of status return to normal, and time and date of alarm acknowledgment.
3. Alarm messages shall be provided in user definable text (English or other user defined language) and shall be accessible either at the Operator's Terminal or via remote (modem) communication. When specified, designated alarms shall be available for dial out to pager alarms for 'on call' personnel.

E. Trendlog Information

1. DDC system shall be capable of periodically monitoring the values or status of selected feedback or control data from the system global controller(s) or field controllers and archiving this information on the operator's terminal. Archived files shall be appended with new sample data, allowing samples to be accumulated over a user defined period. Systems that overwrite previously archived data samples shall not be allowed, unless limited file size is specified. Samples in a trendlog shall be available for viewing at the operator's terminal. Displays of trendlog data shall be in spreadsheet format. Operator

shall be capable of scrolling through all trendlog data. System shall automatically open archive files as needed to display archived data when the operator scrolls through the data vertically. All trendlog information displays shall be shown in standard engineering units.

2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x, y) graphs that display up to six object types at the same time in different colors. Graphs shall show object type values relative to time.
3. Operator shall be able to change trendlog setup information. This shall include the data points and status information being trendlogged as well as the interval at which the information is to be logged. All trendlog functions shall be password protected. The operator shall be capable of viewing or setting up a trendlog for any prompted or read-only item.
4. The system shall provide a means for the operator to directly export data to a comma-delimited file format for use in third-party software spreadsheets or other database programs. The system operation shall not be affected in any way by this data exchange.

F. Energy Log Information

1. DDC system shall periodically gather energy log data stored in field terminal controllers and archive this information on the operator terminal's hard disk. Archive data shall be appended with the new data and allow data to be accumulated over several years. Systems that overwrite archived data shall not be allowed unless limited file size is specified. System shall automatically open archive files as needed to display archived data when the operator scrolls through the data. All energy log information shall be displayed in standard engineering units.
2. System software shall be capable of graphing the Energy Log data. Software shall be capable of creating graphs in two-axis (x, y) format that shows recorded data relative to time. All data shall be stored in comma-delimited file format for direct use by third party software spreadsheets or other database programs. System operation shall not be affected by on-line access to the energy information.
3. Operator shall be able to modify the energy log setup information. This shall include which meters are to be logged, meter pulse value, and what types of energy units are being logged. All energy meters monitored by the system shall be capable of being logged. All energy logging operations shall be password protected.
4. Provide capability for the operator to export to a comma-delimited file format all energy-logged data for use by third party software spreadsheets or other database programs. System operation shall not be affected by on-line access to the energy information.

G. Configuration/Setup

1. Provide means for the operator to display and change the system configuration. This shall include, but not be limited to: system time, day of the week, date of daylight savings time set forward/back, printer termination, port addresses, modem port and speed, and the like. Items shall be modified utilizing easily understood terminology by means of simple mouse/cursor key movements.

H. Programming Tools

1. Operator's Terminal shall include programming tools for all controllers supplied. If a new software package is proposed it is the contractor's responsibility to load all programming tools/ engineering software on all of the owner's existing operator terminals and laptops, as well as provide all connectors for connection to field devices with portable terminals. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from different types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.
2. User shall be able to pick graphical function block from the menu and place on screen. Programming tools shall place lines connecting appropriate function blocks together automatically. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
3. Programming tools shall include a test mode. Test mode shall show user the real-time data on top of graphical display of selected function blocks. Data shall be updated real-time with no interaction by the user. Function blocks shall be animated to show status of data inputs and outputs. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.

2.11 GLOBAL BUILDING CONTROLLERS (GBCs)

- A. The controls contractor shall supply one or more global controller as part of this contract. Number of global controllers required is dependent on the type and quantity of DDC devices.
- B. The Global Building Controller shall provide the interface between the LAN and the field control devices and provide global supervisory control functions over the control devices connected to the GBC. It shall be capable of executing application control programs to provide:
 - a. Calendar functions
 - b. Scheduling
 - c. Trending
 - d. Alarm monitoring and routing
 - e. Time synchronization
 - f. Integration of LonWorks controller data and BACnet controller data
 - g. The GBC must provide the following hardware features as a minimum:
 1. Ethernet Port - 10 Mbps
 2. One RS-232 port
 3. One BACnet MS/TP Port

4. Battery Backup
5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
6. The GBC must be capable of operation over a temperature range of 0 to 55°C
7. The GBC must be capable of withstanding storage temperatures of between 0 and 70°C.
8. The GBC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.
9. The GBC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the GBC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
10. Event Alarm Notification and actions
11. The GBC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
12. The GBC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
13. Alarm generation shall be selectable for annunciation type and acknowledgement requirements.
- h. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
- i. Provide timed (schedule) routing of alarms by class, object, group, or node.
- j. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- k. Control equipment and network failures shall be treated as alarms and annunciated.
- l. Alarms shall be annunciated in any of the following manners as defined by the user:
- m. Screen message text
- n. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
 - i. Day of week
 - ii. Time of day
 - iii. Recipient
- o. Pagers via paging services that initiate a page on receipt of email message

- p. Graphic with flashing alarm object(s)
 - q. Printed message, routed directly to a dedicated alarm printer
 - r. Audio messages
 - s. The following shall be recorded by the NAC for each alarm (at a minimum):
 - i. Time and date
 - ii. Location (building, floor, zone, office number, etc.)
 - iii. Equipment (air handler #, accessway, etc.)
 - iv. Acknowledge time, date, and user who issued acknowledgement.
 - v. Number of occurrences since last acknowledgement.
 - t. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 - u. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
 - v. A log of all alarms shall be maintained by the GBC and/or a server (if configured in the system) and shall be available for review by the user.
 - w. Provide a "query" feature to allow review of specific alarms by user defined parameters.
 - x. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
 - y. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.
- C. Data Collection and Storage
- a. The GBC shall have the ability to collect data for any property of any object and store this data for future use.
 - b. The data collection shall be performed by log objects, resident in the GBC that shall have, at a minimum, the following configurable properties:
 - c. Designating the log as interval or deviation.
 - d. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
 - e. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
 - f. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.

- g. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
- h. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
- i. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
- j. All log data shall be available to the user in the following data formats:
 - k. HTML
 - l. XML
 - m. Plain Text
 - n. Comma or tab separated values
 - o. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
- p. The GBC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other GBC on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - q. Archive on time of day
 - r. Archive on user-defined number of data stores in the log (buffer size)
 - s. Archive when log has reached its user-defined capacity of data stores
 - t. Provide ability to clear logs once archived
- D. AUDIT LOG
 - a. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
 - b. Time and date
 - c. User ID
 - d. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.
- E. DATABASE BACKUP AND STORAGE
 - a. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
 - b. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.

- c. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XMLformat is supported.

2.12 ROUTER, CONVERTER, OR REPEATER

Routing functions shall be performed using only BACnet standard protocols as defined by ASHRAE Standard 135-1995. The converter interconnects a standard computer serial port with an MS/TP LAN. Repeater functions shall be handled by a device to selectively interconnect four (4) portions of MS/TP LAN as a minimum.

1. ROUTERS: The router function shall perform the BACnet definition functions of interconnecting two or more BACnet LANs together, forming a BACnet internetwork. The router shall have optional plug-in boards permitting the following BACnet communication methods:
 - a. The router shall have the routing functionality of interconnecting BACnet Ethernet and/or ARCNET high-speed LAN to BACnet MS/TP LAN and/or more PTP LAN.
 - b. The router shall have capability of interconnecting BACnet Ethernet high-speed LAN to BACnet ARCNET high-speed LAN.
 - c. BACnet PTP (RS-232 point-to-point) communication shall be available on the global controller by including an (optional) modem. The PTP modem option shall operate under the BACnet half-router communication protocol.
 - d. BACnet messages may be routed to all LANs installed on the router at the same time with no operator intervention.
2. CONVERTER: A converter shall (optionally) be provided to interface an (optional) portable field service computer from its serial port (RS-232) to the BACnet MS/TP LAN (RS-485).
3. REPEATERS: BACnet repeaters shall provide selective interconnection to 4-segments of MS/TP LAN as a minimum. The repeater shall be an active device, containing logic capable of detecting and repeating signals from one MS/TP LAN segment to all other segments. Repeaters shall permit additional nodes to be added to the MS/TP LAN, up to a maximum of 128 nodes.

3.1 GENERAL CONTROLS INSTRUMENTATION

A. Control Panels:

1. Panels shall have hinged doors and be marked with engraved labels. Panels used as a location for mounting control devices shall have a document holder located on the inside of the door.
2. Provide common keying for all panels.
3. Entrance and exit wiring should be on the panel sides.
4. All heat generating devices shall be located at the top of the panel.
5. Combined Temperature and Carbon Dioxide Sensors:

- a. Where indicated on plans, a combined temperature and carbon dioxide sensor shall be provided in a single package. Combined sensor shall be Telaire Airestat Model 5010 or as manufactured by Veris CDW/E series. Housing shall be blank with a momentary pushbutton for override of unoccupied operation. The carbon dioxide sensor shall be non-dispersive infrared type with an accuracy of ± 100 ppm or 7% of the reading (whichever is greater). Elevation correction adjustment and software for self-correction of drift to better than ± 10 ppm per year shall be incorporated.
- b. Temperature sensors shall be capable of being replaced without the need for controller re-calibration. Temperature sensors shall accordingly have manufactured space temperature and setpoint signal precision tolerances of no greater than 1°F.

6. Temperature Sensors:

- a. All internal temperature sensors for air handler and unit temperature readings shall be temperature averaging cable that spans across the full face of the associated coil. Install per manufacturer requirements.

B. Labels and Tags:

1. Provide labels for all field devices including sensors, meters, transmitters and relays. Labels shall be plastic laminate and located adjacent to the device.
2. Labels of field devices (both locally and software ID's) shall be associated with their respective air handler, boiler, chiller, etc.

3.2 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required. Thermistor sensing, RTD and transmitter sensing is acceptable for any application.

B. Fan Coil Unit Thermostats and other Thermistor Temperature Sensors (type II) and Transmitters:

1. Accuracy: Plus, or minus 1 deg F at calibration point.
2. Wire: as recommended by building automation system provider.
3. Insertion Elements in Ducts: Single point, length as required by application.
4. Averaging Elements in Ducts: 12 inches.
5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
6. Room Sensor: Sensor with lever setpoint adjust, on/override to.
7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:

1. Accuracy: Plus, or minus 1 deg F at calibration point.
 2. Wire: as recommended by building automation system provider.
 3. Insertion Elements in Ducts: Single point, length as required by application.
 4. Averaging Elements in Ducts: 12 inches.
 5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
 6. Room Sensor: Space sensor located in public area (corridors, lobby, etc) shall be metallic wall plate type 2 thermistor with no logo or adjustment dial. Or sensor with setpoint adjust, on/override to match existing.
 7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- D. Humidity Sensors: Bulk polymer sensor element.
1. Accuracy: 3 percent full range with linear output.
 2. Room Sensor Range: 20 to 80 percent relative humidity.
 3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 4. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
 5. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 0 to 120 degrees.
 6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
- E. Pressure Transmitters/Transducers:
1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 1-inch wg .
 - d. Duct Static-Pressure Range: 0- to 5-inch wg.
 2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
 3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
 4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
 5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

3.3 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa). Or current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 120 percent of rated motor current.
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 120 percent of rated motor current.
- D. Status of fans, pumps, or motor using current switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- E. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

3.4 CO2 and CO sensors

- A. Carbon Dioxide and Carbon Monoxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and factory calibrated, with continuous or averaged reading, 4- to 20-mA output; for wall mounting or duct mounting as required by application.

3.5 AIR/WATER FLOW MEASURING STATIONS

- A. Duct Airflow Station: Air flow station to be provided by controls contractor.
 - 1. Casing: Galvanized-steel frame.
 - 2. Ebtron thermal dispersment technology type is acceptable.
 - 3. For water flow Onicon flow meter (OR AS NOTED ON PLANS)

3.6 THERMOSTATS

- A. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
 - 1. Label switches ["FAN ON-OFF"].
 - 2. Mount on single electric switch box.

- B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
- C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
 - 1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 - 2. Selector Switch: Integral, manual on-off-auto.
- D. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
 - 1. Bulbs in water lines with separate wells of same material as bulb.
 - 2. Bulbs in air ducts with flanges and shields.
 - 3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
 - 4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 - 5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 - 6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- E. Fire-Protection Thermostats where shown on plans or points list: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:
 - 1. Reset: Manual.
 - 2. Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
- F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- G. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-]reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
 - 1. Bulb Length: Minimum 10 feet.
 - 2. Quantity: As required by application.

- H. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.
 - 1. Bulb Length: Minimum 10 feet.
 - 2. Quantity: As required by application.

3.7 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 2. Actuator on VAV, FCU, UV, Blower coil terminal unit valves are failed in place floating signal type.
 - 3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 - 4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 - 5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 - 6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 - 2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24 V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
9. Tri-state: Floating signal.
10. Temperature Rating: 40 to 104 deg F (5 to 40 deg C).
11. Run Time: Sized as required for application.

3.8 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. The manufacturer shall warrant all components a period of 5 years from the date of production, with the first two years unconditional.
- C. Manufacturers:
 1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
 2. Erie Controls.
 3. Hayward Industrial Products, Inc.
 4. Belimo
- D. Pressure Independent Control Valves
 1. Dynamic control valve shall accurately control flow, independent of system pressure fluctuation. Pressure independent control valves shall be provided on all hot water and chilled water coils for all new and existing air handling units.
 2. Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure.
 3. Valve shall be electronic, dynamic, modulating 2-way control.
 4. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.
 5. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
 6. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system.
 7. External LED readout of current valve position and maximum valve position setting shall be standard.
 8. Optional fail-safe system to power valve to either open or closed position from any position in case of power failure shall be available.

9. Flow regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"–1-1/2") or 316 Stainless Steel and EPDM (2"–6").
10. Flow regulation unit shall be accessible for maintenance.
11. Accuracy: The control valves shall accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSID across the valve.
12. Close-Off Pressure Rating: 200 PSI.
13. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
14. The use of pressure independent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is not acceptable.
15. NPS 2" and smaller pressure independent control valves for individual coil control shall be provided as part of a pipe package supplied by the valve manufacturer. The supply side of the coil shall contain an integrated isolation ball valve/manual air vent with a P/T port. The return side shall contain a union fitting with a P/T port, pressure independent control valve, an integrated isolation ball valve/manual air vent with a P/T port. Shut-off valves as an integrated part of the pressure independent control valve are prohibited.

E. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
4. Sizing: 3 to 5 psi maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - c. Three-Way Modulating: Twice the load pressure drops, but not more than value specified above.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

- F. Butterfly Valves: 200-psig (1380-kPa), maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
 - 1. Body Style: Wafer.
 - 2. Disc Type: Nickel-plated ductile iron.
 - 3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
- G. Terminal Unit Control Valves (VAV, FCU, UV): Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
 - 1. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
 - 2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
 - 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Actuator is floating signal fail in place type.

3.9 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
 - 1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 - 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
 - 4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

3.10 CONTROL CABLE

- A. HVAC control systems shall be full DDC. All control wiring in the cable tray shall use purple and yellow colored plenum rated cable. Each color shall be consistent for the entire project

and noted on the plans. Blue should be used for the primary network cable and yellow for the secondary network connections.

3.11 CENTRAL PLANT AND DOAS LOGIC CONTROLLERS

- A. Provide one or more native BACnet logic controllers for each air handler and provide native BACnet logic controllers as needed for central plant control that adequately cover all objects listed in the object list ("points list"). Provide for spare inputs and outputs on controllers. All controllers shall interface to global controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable. No auxiliary or non-BACnet controllers shall be used.
- B. BACnet Conformance:
 - 1. Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet devices. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 - 2. Refer to Section 22.2, BACnet Functional Groups, in the BACnet Standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 - 3. Standard BACnet object types supported shall include as a minimum – Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Logic controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on the controller may be either analog or binary. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display (Alerton Microset). Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0-10 VDC or 4-20 mA. Software shall include scaling features for analog outputs. Logic controller shall include 24 VDC voltage supplies for use as power supply to external sensors.
- D. All program sequences shall be stored on board the logic controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by the controller a minimum of ten times per second and be capable of multiple PID loops for control of multiple devices. All calculations shall be complete using floating-point math and system shall support display of all information in floating-point nomenclature at the operator's terminal.

- E. Programming of logic controllers shall be completely modifiable in the field over the installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Logic controller shall be programmed using programming tools as described in the Operator's Terminal section of this specification.
- F. All programming tools shall be provided as part of the system. Provide documentation in flowchart form of all programming as part of the final system as-built documentation.
- G. Logic controller shall include software-scheduling functions on board without depending on any external device. Scheduling shall be via a BACnet schedule object for seven-day-of-the-week scheduling. Controller shall include interface capability for optional plug-in hardware clock with battery back-up. Provide optional hardware clock as shown on object drawing list included in the Contract Documents (plans or specifications).
- H. Logic controller shall include support for intelligent field sensor (Alerton Microset). Display on field sensor shall be programmable at logic controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See Sequences of Operation for specific display requirements at intelligent field sensor.

3.12 TERMINAL UNIT CONTROLLERS

- A. Provide one native BACnet programmable logic controller for each piece of unitary mechanical equipment that adequately covers all objects listed in the object list for the unit. All controllers shall interface to the global controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic programs as needed for complete control of the unit.
- B. BACnet Conformance
 - 1. Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps as a native BACnet device. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 - 2. Refer to Section 22.2, BACnet Functional Groups, in the BACnet Standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 - 3. Standard BACnet object types supported shall include as a minimum – Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Logic controllers shall include universal inputs with 10-bit resolution and that can accept 3K and 10K thermistors, 0-5 VDC, 4-20 mA and dry contact signals. Any input controller may be

either analog or binary. Controller shall also include support and modifiable programming for interface to intelligent room sensor (Alerton Microset). Controllers shall include binary outputs on board.

- D. All program sequences shall be stored on board logic controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by the controller ten (10) times per second and shall be capable of multiple PID loops for control of multiple devices.
- E. Programming of logic controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Logic controller shall be programmed using programming tools as described in Operator Terminal section of this specification.
- F. All programming tools shall be provided as a part of the system. Provide documentation in flowchart form of all programming as part of the final system as-built documentation.
- G. Logic controller shall include software-scheduling functions on board without depending on any external device. Scheduling shall be via BACnet schedule object for seven-day-of-the-week scheduling. Controller shall include interface capability for optional plug-in hardware clock with battery back up. Provide optional hardware clock as shown on the object list included with the Contract Documents (plans and specifications).
- H. Logic controller shall include support for intelligent field sensor (Alerton Microset). Display on field sensor shall be programmable at logic controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See Sequence of Operation for specific display requirements at intelligent field sensor.

3.13 UTILITY MONITORING SOFTWARE INTEGRATION

- A. The Systems Integrator is responsible for providing trends for integration into the BAS.
- B. All points from all noted utilities to be monitored shall be compiled, and actively displayed with the new building BAS System.
- C. System shall provide browser access to unit controllers and associated setpoints and tuning parameters. The Building Automation System shall be comprised of BACnet or LonMark/LonTalk controllers. Should the NAC network connection be interrupted, the DDC components shall continue to provide local control using the last known state of any global variables (OA temperature, Demand Value, Price of Energy, etc.) It shall be the DDC contractor's responsibility to effectively design and program standalone control while coordinating the required DDC integration and communication to the NAC.

PART 3 - EXECUTION

3.01 TRAINING

- A. The Controls Contractor shall provide complete on-site training for the Owner's designated

operating personnel. Training shall include all functional aspects of the control system and all modes of system operation. System modes include occupied/unoccupied, heating/cooling, economizer, startup/shutdown, energy management, and alarm event operations. Training of Owner's operating personnel shall include a minimum of eight (8) hours of system instruction, conducted during one or two site visits for a combined total of eight hours of instruction. Additional instruction time may be requested by the Owner for an additional fee if needed for training additional personnel or if more instruction is requested. Training is not intended to include in-depth instruction in system programming.

- B. Training shall be conducted during normal working hours, Monday through Friday, at the project site. When applicable, the training may be conducted at the Owner's central energy management office in addition to training on site.

- C. Contractor shall furnish one (1) copy of the system Operator's Manual to the Owner. This manual should be delivered to the Owner at the time of training. This manual is in addition to the system As-built documents which are intended to show wiring configurations and sensor locations.

END OF SECTION 23 0900

SECTION 23 2300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- B. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.3 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.4 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L
- B. Wrought-Copper Fittings: ASME B16.22.

- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 - 5. Seal Cap: Forged-brass or valox hex cap.
 - 6. End Connections: Socket, union, threaded, or flanged.
 - 7. Working Pressure Rating: 500 psig.
 - 8. Maximum Operating Temperature: 275 deg F.
- C. Check Valves:
 - 1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
 - 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.

3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg.
6. Superheat: Adjustable.

7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: as indicated on the drawings.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

- L. Permanent Filter Dryers: Comply with ARI 730.
 - 1. Body and Cover: Painted-steel shell.
 - 2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
 - 3. Desiccant Media: Activated charcoal.
 - 4. Designed for reverse flow (for heat-pump applications).
 - 5. End Connections: Socket.
 - 6. Access Ports: NPS ¼ connections at entering and leaving sides for pressure differential measurement.
 - 7. Maximum Pressure Loss: 2 psig.
 - 8. Rated Flow: tons as indicated on the drawings
 - 9. Working Pressure Rating: 500 psig.
 - 10. Maximum Operating Temperature: 240 deg F.
- M. Liquid Accumulators: Comply with ARI 495.
 - 1. Body: Welded steel with corrosion-resistant coating.
 - 2. End Connections: Socket or threaded.
 - 3. Working Pressure Rating: 500 psig.
 - 4. Maximum Operating Temperature: 275 deg F.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
 - 1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 - 2. NPS 1-1/2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
 - 3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

- 4. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- G. Safety-Relief-Valve Discharge Piping:
 - 1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 - 2. NPS 1-1/2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
 - 3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
 - 4. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping in accordance with the equipment manufacturer's recommendations.
- C. Install refrigerant piping according to ASHRAE 15.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

3.4 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches minimum rod size, 1/4 inch
2. NPS 5/8 Maximum span, 60 inches minimum rod size, 1/4 inch
3. NPS 1 Maximum span, 72 inches minimum rod size, 1/4 inch
4. NPS 1-1/4 Maximum span, 96 inches minimum rod size, 3/8 inch
5. NPS 1-1/2 Maximum span, 96 inches minimum rod size, 3/8 inch
6. NPS 2 Maximum span, 96 inches minimum rod size, 3/8 inch
7. NPS 2-1/2 Maximum span, 108 inches minimum rod size, 3/8 inch
8. NPS 3 Maximum span, 10 feet minimum rod size, 3/8 inch
9. NPS 4 Maximum span, 12 feet minimum rod size, 1/2 inch

C. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Verify that compressor oil level is correct.
 - 2. Open compressor suction and discharge valves.
 - 3. Open refrigerant valves except bypass valves that are used for other purposes.
 - 4. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 2300

SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Single-wall rectangular ducts and fittings.
 - 2. Single wall round ducts and fittings.
 - 3. Double wall round ducts and fittings.
 - 4. Sheet metal materials.
 - 5. Sealants and gaskets.
 - 6. Hangers and supports.

- B. Related Sections:

- 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 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. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
 - 1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
 - 2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
 - 3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

1.4 SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Adhesives.
 - 2. Sealants and gaskets.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.
 - 9. Penetrations through fire-rated and other partitions.
 - 10. Equipment installation based on equipment being used on Project.
 - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
- C. Delegated-Design Submittal:
 - 1. Sheet metal thicknesses.
 - 2. Joint and seam construction and sealing.
 - 3. Reinforcement details and spacing.
 - 4. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.
- D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - 2. Suspended ceiling components.

3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.

- E. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
 - f. Hamlin
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Lindab Inc.
 2. McGill AirFlow LLC.
 3. SEMCO Incorporated.
 4. Sheet Metal Connectors, Inc.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

- b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 - 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
 - E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.
 - F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
- 2.4 SHEET METAL MATERIALS
- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 - B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
 - C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
 - D. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 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.
- 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.

2.5 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, use sealant that has 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. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.

3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. All medium pressure supply mains from built-up Air Handling Units to the terminal box connections.
 - b. Low pressure supply ducts (single zone units and supply ductwork downstream of terminal boxes): Test representative duct sections, totaling no less than 10 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before applying external insulation.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new 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 Division 23 Section "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel unless noted otherwise.

B. Supply Ducts:

1. Ducts Connected to Indoor Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
2. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 3-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.

- d. SMACNA Leakage Class for Round and Flat Oval: 4.

C. Return Ducts:

1. Ducts Connected to Indoor Units and Packaged Heat Pumps:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4.
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 3-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4.
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

- a. Pressure Class: Negative 2-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4.
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 3-inch wg, or as applicable for fan static pressure listed in schedules.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Indoor Units or Packaged Heat Pumps:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4.
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 2-inch wg.

- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 4.
- d. SMACNA Leakage Class for Round and Flat Oval: 4.

F. Intermediate Reinforcement:

- 1. Galvanized-Steel Ducts: Galvanized steel.
- 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- 3. Aluminum Ducts: Aluminum.

G. Double-Wall Duct Interstitial Insulation:

- 1. Supply Air Ducts: 1 inch thick.
- 2. Return Air Ducts: 1 inch thick.

H. Elbow Configuration:

- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "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 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- I. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 3113

SECTION 23 3300 - AIR DUCT ACCESSORIES

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. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Turning vanes.
10. Remote damper operators.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Flexible ducts.
14. Duct accessory hardware.
15. Airflow Monitoring Stations

- B. Related Sections:

1. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

- A. Product Data: 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. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances, and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
 - f. Wiring Diagrams: For power, signal, and control wiring.
- C. Source quality-control reports.
- D. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- 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 AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304.
- D. 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.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.; a division of Mestek, Inc.
 - 2. American Warming and Ventilating; a division of Mestek, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff; a division of PCI Industries, Inc.
 - 6. Ruskin Company.
 - 7. SEMCO Incorporated.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1500 fpm.
- D. Maximum System Pressure: 2-inch wg.
- E. Maximum Leakage: 40" wide, 1% of max. flow.
- F. Frame: 0.09-inch- thick extruded aluminum, with welded corners.
- G. Blades: Multiple single-piece blades, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.
- H. Blade Action: Parallel.

- I. Blade Seals: Extruded vinyl, mechanically locked.
- J. Blade Axles:
 - 1. Material: Aluminum.
 - 2. Diameter: 0.20 inch.
- K. Tie Bars and Brackets: Aluminum.
- L. Return Spring: Adjustable tension.
- M. Bearings: Steel ball or synthetic pivot bushings.
- N. Accessories: (as noted on plans or required by installation)
 - 1. Electric actuators.
 - 2. Chain pulls.
 - 3. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20-gage minimum.
 - b. Sleeve Length: 6 inches minimum.
 - 4. Screen Mounting: Rear mounted.
 - 5. Screen Material: Aluminum.
 - 6. Screen Type: Bird or Insect (as noted on drawings)
 - 7. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.; a division of Mestek, Inc.
 - 2. American Warming and Ventilating; a division of Mestek, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff; a division of PCI Industries, Inc.
 - 6. Ruskin Company.
 - 7. SEMCO Incorporated.
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: 2-inch wg.

- E. Maximum Leakage: 40" wide, 1% of max. flow.
- F. Frame: 0.09-inch- thick extruded aluminum, with welded corners.
- G. Blades:
 - 1. Multiple, 0.025-inch- thick, roll-formed aluminum.
 - 2. Maximum Width: 2 inches.
 - 3. Action: Parallel.
 - 4. Balance: Gravity.
 - 5. Eccentrically pivoted.
- H. Blade Seals: Vinyl.
- I. Blade Axles: ½" diameter synthetic
- J. Tie Bars and Brackets:
 - 1. Material: Aluminum.
 - 2. Rattle free with 90-degree stop.
- K. Return Spring: Adjustable tension.
- L. Bearings: Synthetic.
- M. Accessories: (as noted on plans or required by installation)
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Flange on intake.

2.4 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Ruskin Company.
 - 2. Suitable for horizontal or vertical applications.

3. Frames:
 - a. Hat-shaped, galvanized-steel channels, 16-gauge minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 16-gauge thick.
5. Blade Axles: Galvanized steel.
6. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.

2.5 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Warming and Ventilating; a division of Mestek, Inc.
 2. Greenheck Fan Corporation.
 3. METALAIR, Inc.
 4. Metal Form Manufacturing, Inc.
 5. Nailor Industries Inc.
 6. Ruskin Company.
- B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
 1. Hat shaped.
 2. Galvanized-steel channels, 0.064 inch thick.
 3. Mitered and welded corners.
- D. Blades:
 1. Multiple blade with maximum blade width of 8 inches, airfoil design.

2. Opposed-blade design.
 3. Galvanized steel.
 4. 14-gauge thickness.
 5. Blade Edging: Closed-cell neoprene edging.
 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- E. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
1. Stainless-steel sleeve.
 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Per plans
- B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 20-gauge galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.052 or 0.138-inch-thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links (unless noted otherwise).

2.7 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Per plans
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links (unless noted otherwise).
- G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.
- H. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Leakage: Class I.
- J. Rated pressure and velocity to exceed design airflow conditions.
- K. Mounting Sleeve: Factory-installed, 20-gauge thickness, galvanized sheet steel; length to suit wall or floor application.
- L. Master control panel for use in dynamic smoke-management systems.
- M. Damper Motors: Modulating or two-position action.
- N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control for HVAC." and Division 26 Sections.
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 7. Electrical Connection: 120V or 24V as noted on the drawings.
- O. Accessories: (as indicated on the drawings)
1. Auxiliary switches for position indication.
 2. Momentary test switch, damper mounted.

2.8 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall for ducts up to 30 inches wide and double wall for larger dimensions.

2.9 REMOTE DAMPER OPERATORS

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

1. Pottorff; a division of PCI Industries, Inc.
2. Ventfabrics, Inc.
3. Young Regulator Company.
4. Metropolitan.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed, 3/4 inches deep.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.10 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Ductmate Industries, Inc.
3. Greenheck Fan Corporation.
4. McGill AirFlow LLC.
5. Nailor Industries Inc.
6. Pottorff; a division of PCI Industries, Inc.
7. Ruskin

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.

- d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

- 1. Door and Frame Material: Galvanized sheet steel.
- 2. Door: Single wall, 12-gauge.
- 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
- 4. Factory set at 2" to 10" for positive pressure and -4" to -10" for negative pressure.
- 5. Doors close when pressures are within set-point range.
- 6. Hinge: Continuous piano.
- 7. Latches: Cam.
- 8. Seal: Neoprene or foam rubber.
- 9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.11 FLEXIBLE CONNECTORS

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

- 1. Ductmate Industries, Inc.
- 2. Duro Dyne Inc.
- 3. Ventfabrics, Inc.
- 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 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.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

- 1. Minimum Weight: 26 oz./sq. yd.
- 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
- 3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

- 1. Minimum Weight: 24 oz./sq. yd.
- 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
- 3. Service Temperature: Minus 50 to plus 250 deg F.

- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd.
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.
- 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.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.12 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Flexmaster U.S.A., Inc.
 - 2. McGill AirFlow LLC.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10 to plus 160 deg F.
- C. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 20 to plus 250 deg F.
 - 4. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2007.

D. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or nylon strap in sizes 3 through 18 inches, to suit duct size.

2.13 DUCT ACCESSORY HARDWARE

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

2.14 AIRFLOW MONITORING STATIONS

- A. Air Measuring Stations to be furnished under this section of specification and installed under Division 23 Section. Provide where indicated and scheduled, an airflow measuring element assembly capable of continuously monitoring the airflow capacity in the duct.
 1. The airflow sensing elements shall be constructed of 6000 Series extruded aluminum, forming two (2) integral chambers for Total and Static pressure averaging, without the physical presence of forward projecting sensors. Individual Total and Static pressure sensing elements are not acceptable.
 2. The number of sensing ports on each element, and the quantity of elements utilized at each installation, shall comply with the ASHRAE Standard #111 for duct traversing. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without amplification nor flow correction (K factors), or field calibration, with an accuracy of 2% of actual flow for operating velocities as low as 100 feet per minute.
 3. The airflow elements shall not induce a pressure drop greater than .03" Water Column at 2000 FPM, nor shall the sound level within the duct be amplified by its presence in the air stream. Each airflow measuring element shall contain multiple Total and Static pressure sensors.
 4. Where primary flow elements are located outside of the manufacturers published installation guidelines the manufacturer shall be consulted, and approve of any special configurations, such as air equalizers and/or additional and strategically placed measuring points as may be required.

5. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inches to three inches to facilitate matching connecting ductwork.
 6. The main take-off point from both the total pressure and the static pressure elements MUST be symmetrical. The probes shall be mounted in an eight-inch-deep, 16-gauge galvanized steel casing with 90-degree undrilled flanges, fabricated to the duct size, and shall contain multiple airflow traverse elements interconnected as herein before described.
 7. An identification label shall be placed on each element listing the Model No., System Served, Size and Identifying Tag Number.
 8. The airflow measuring element shall be by Ebtron (or approval equal).
- B. Airflow Indicating Transducers to be furnished and installed under this section of the specification.
1. Provide individual airflow transducers, especially selected for the required design operating spans of each of the above primary elements.
 2. The electronic flow transducer(s) shall be solid-state analog type, with infinite resolution to facilitate volume tracking control functions. Microprocessor based transducers with time-sharing of multiple square root extractors and/or controllers are not acceptable.
 3. The transducer(s) shall be housed in a NEMA 1 enclosure with integral terminal strip for field wiring, and power and output signal conduit connection port.
 4. Each transducer's output shall not be affected by direction of mounting (attitude) or external vibrations and shall be furnished with a factory calibrated span. The analog output signal shall be linear to air volume, which is factory set for a full-scale value equal to 110% of the maximum design capacity of the flow measuring element served for variable air volume applications, or 200% of the design operating value for constant volume applications.
 5. Electronic transducers shall operate on 16 to 36 VDC: Transducer(s) shall have outputs of 4 to 20 mA/2-wire or 0-10VDC/3-wire.
 6. Each transducer shall be provided with a local indicating meter. The local digital indicating meter shall be one half-inch high, three- and one-half digit liquid crystal display (LCD) type. The LCD shall indicate the measured air volume in engineering units of cubic feet per minute (CFM). The meter shall be calibrated to an accuracy of + 1 count.

7. Transducer performance shall be equal or better than the following:

Hysteresis: +0.05%
Linearity: +0.4%
Repeatability: +0.1%
Temperature Effects: $< +0.03\% \text{ F.S.} / ^\circ\text{F}$
Over-pressure: 5 PSIG Proof
Response: < 0.25 seconds for full span input
Noise Filtration: Low Pass Filter, factory set @ 3.2Hz
Transducer Span: < 2 times the design velocity pressure @ maximum flow
Accuracy: $+0.5\% \text{ F.S. (Terminal Point)} / +0.35\% \text{ F.S. (BFSL)}$

8. The airflow indicating transducers shall be the FIT-1001D as manufactured by Ebtron (or approval equal).

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 backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.

- G. Install fire and smoke dampers according to UL listing and manufacturer's instructions.
- H. Connect ducts to duct silencers with flexible duct connectors.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At drain pans and seals.
 - 4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 5. 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.
 - 6. Control devices requiring inspection.
 - 7. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- L. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Connect terminal units to supply ducts directly or with maximum 6-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- P. Connect diffusers or light troffer boots to ducts with maximum 48-inch lengths of flexible duct clamped or strapped in place.
- Q. Connect flexible ducts to metal ducts with approved strap and sealant.

- R. Install duct test holes where required for testing and balancing purposes.
- S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that 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.

END OF SECTION 23 3300

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. See fan schedule on drawings for additional requirements and specific options required for each fan.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.4 ACCEPTABLE MANUFACTURERS

- A. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.5 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.

- 5. Dampers, including housings, linkages, and operators.
- 6. Roof curbs.
- 7. Fan speed controllers.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, wiring diagrams, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Operation and Maintenance Data: For power ventilators to include operation and maintenance manuals.

1.6 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. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. 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 IN-LINE CENTRIFUGAL FANS

- A. Description: In-line, direct- or belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 3. Companion Flanges: For inlet and outlet duct connections.
 - 4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 5. Motor and Drive Cover (Belt Guard): Galvanized steel.
- G. Capacities and Characteristics: As indicated on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support units using spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - 1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

- C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION 23 3423

SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular and square ceiling diffusers.
 - 2. Perforated diffusers.
 - 3. Louver face diffusers.
- B. Related Sections:
 - 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACCEPTABLE MANUFACTURERS

- A. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.4 SUBMITTALS

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

- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.
- D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.
- E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

- A. Rectangular and Square Ceiling Diffusers:
 - 1. Devices shall be specifically designed for variable-air-volume flows.
 - 2. Material: Steel or Aluminum as indicated on the drawings.
 - 3. Finish: Baked enamel, white unless noted otherwise.
 - 4. Face Size: 24 by 24 inches or as indicated on the drawings.
 - 5. Face Style: Four cone.
 - 6. Mounting: As required.
 - 7. Pattern: Fixed.
 - 8. Dampers: Radial opposed blade.
- B. Perforated Diffuser:
 - 1. Devices shall be specifically designed for variable-air-volume flows.
 - 2. Material: Steel backpan and pattern controllers, with steel or aluminum face as indicated on the drawings.
 - 3. Finish: Baked enamel, white unless noted otherwise.
 - 4. Face Size: 24 by 24 inches or as indicated on the drawings.
 - 5. Duct Inlet: Round or Square as indicated on the drawings.
 - 6. Face Style: Flush.
 - 7. Mounting: T-bar.
 - 8. Pattern Controller: Adjustable with louvered pattern modules at inlet.

9. Dampers: Radial opposed blade.

C. Louver Face Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum as indicated on the drawings.
3. Finish: Baked enamel, white unless noted otherwise.
4. Face Size: As indicated on the drawings.
5. Mounting: As required.
6. Pattern: Four-way core style, unless noted otherwise.
7. Dampers: Radial opposed blade.

2.2 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.

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 23 3713

SECTION 23 5250 – VRF EQUIPMENT

PART 1: GENERAL

1.1 SECTION INCLUDES

- A. System Heat Recovery Condensing Unit
- B. Zone Ducted Unit
- C. Zone Cassette Unit
- D. Zone Wall-mounted unit
- E. Zone Floor-mounted unit

1.2 RELATED SECTIONS

- A. Section 15170 - Motors.
- B. Section 15242 - Vibration Isolation.
- C. Section 15290 - Ductwork Insulation.
- D. Section 15885 - Air Cleaning.
- E. Section 15952 - Controls and Instrumentation.
- F. Section 16180 - Equipment Wiring Systems.

1.3 SUBMITTALS

- A. Submit unit performance data including capacity, nominal and operating performance.
- B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
- D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.
- E. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.
- F. The manufacturer shall use manufacturer's VRF selection software for a complete design of the refrigerant pipe lengths, sizing, and other required specialties. Submittals shall include

pipe lengths, number of elbows, controls wiring, power wiring diagram, additional refrigerant charge, and other appurtenances required for a complete and operational system.

1.4 DELIVERY, STORAGE and HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.5 WARRANTY

- A. Equipment warranty shall be from date of substantial completion, as agreed to by the owner, or date of owner occupancy, whichever comes first.
- B. Provide parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- C. Provide five-year extended parts warranty for compressors.

1.5 SIMULTANEOUS COOLING AND HEATING VRF SYSTEM

Heat recovery system shall be an air cooled, system consisting of one to three outdoor unit(s) connected to zone refrigerant distribution systems and indoor units. Zone distribution systems shall allow simultaneous heating and cooling of individual zones. Communication between components shall be provided as an integrated feature of the VRF system. The heat recovery system shall be capable of operating with 208 Volt, 60Hz, 3 phase power.

1.6 REFERENCES

- A. Heat recovery systems shall have published performance ratings certified by AHRI (Air-Conditioning, Heating, and Refrigeration Institute) and listed in the AHRI Standard 1230 certified product directory www.AHRI.net.org.
- B. Heat recovery system components shall be manufactured in production facilities maintaining the following ISO certifications:
 - a) ISO 9001 Quality Management System
 - b) ISO 14001 Environmental Management System
- C. Heat recovery system components shall comply with Underwriters Laboratories (UL) 1995 Heating and Cooling Equipment Standard for Safety and bear the Electrical Testing Laboratories (ETL) label.
- D. Heat recovery system field provided electrical power wiring shall be installed according to

National Electrical Code (NEC) and all local authorities having jurisdiction (AHJs)

1.7 EXTRA MATERIALS

- A. Provide one set of operational filters and set of spare filters.

PART 2: PRODUCTS

2.1 SUMMARY

- A. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.2 GENERAL UNIT DESCRIPTION

Variable Refrigerant Flow (VRF) HVAC system shall be a variable capacity, direct expansion (DX) heat recovery engineered system. The outdoor unit shall consist of one or more cabinet(s) connected through common refrigerant piping. Each system shall have single or multiple, inverter compressor(s). Each system shall be connected to multiple indoor units (IDUs - ducted, non-ducted or combination thereof) through a common refrigerant piping and integrated system controls. Each indoor unit shall be controlled individually. Additionally, heat recovery system shall be capable of simultaneous heating and cooling individual zone(s).

2.3 SYSTEM HEAT RECOVERY CONDENSING UNIT

- A. Outdoor Unit shall be capable of maintaining continuous compressor operation under all of the following operating ambient air conditions.
 - a) Heat Recovery System
 - (i) All IDUs Cooling: 14°F DB to 122°F DB
 - (ii) All IDUs Heating: -13°F WB to 61°F WB
 - (iii) Cooling based synchronous: 14°F DB to 81°F DB
 - (iv) Heating-based synchronous: 14°F WB to 61°F WB
- B. The VRF system shall maintain normal heating and/or cooling operation at all IDUs while any one IDU is powered down for service. When power is restored to the IDU serviced, normal operation shall be restored with no system shutdown, interruption, reset, or power cycling of the outdoor unit.

- C. The air-conditioning system shall use R410A refrigerant.
- D. Each system shall have one, two or three air source outdoor units.
- E. Multi-frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kit and field provided interconnecting pipe to form a common refrigerant circuit.
- F. Refrigerant circuit configuration for Heat Recovery System
 - a. The refrigerant circuit shall be constructed using field provided copper piped together with manufacturer supplied zone distribution system(s) and Y- branches or Header fittings connected to multiple (ducted, non-ducted or combination thereof) indoor units to effectively and efficiently control the simultaneous heating and cooling operation of the VRF system.
 - b. Each refrigerant pipe, y-branch, header kit, elbows and valves shall be individually insulated with no air gaps. All joints shall be glued and sealed.
- G. Factory installed microprocessor controls in the outdoor unit(s), HR unit(s), and indoor unit(s) shall perform functions to efficiently operate the VRF system and communicate in a daisy chain configuration between outdoor unit and HR unit(s) and indoor unit(s) over a RS485 18AWG stranded and twisted wire data link.
- H. The system shall be designed to accept connection up to 64 indoor units.
- I. The total nominal capacity of all indoor units shall be no less than 50% and no more than 130% of outdoor unit's nominal capacity to ensure the VRF system will have sufficient capacity to meet the building's cooling and heating load at design day weather conditions.
- J. The maximum allowable system combination ratio shall be 130%. Systems designed with a combination ratio above 130% will not be accepted.
- K. Each outdoor unit refrigerant circuit shall have a high-pressure safety threaded rupture disk or threaded fusible plug fitting.
- L. The outdoor unit assembly, indoor unit assembly and/or zone distribution system assembly shall be shipped from the factory assembled and pressure tested including internal refrigerant piping, compressor, contacts, relay(s), control components, power and communications wiring necessary.

M. Each outdoor unit refrigeration circuit shall have the following components:

- a. Inverter variable speed compressor(s)
- b. Outdoor unit heat exchanger
- c. Refrigerant strainer(s)
- d. Check valve(s)
- e. Oil separator
- f. Accumulator
- g. Heat exchanger circuiting control
- h. Electronic expansion valve(s)
- i. 4-way reversing valve
- j. Sub-cooler circuit with controls
- k. High and low side Schrader valve service ports with caps.
- l. Service valves

N. Each outdoor unit frame shall have a stand-alone microprocessor control that varies the use of the outdoor coil circuits to optimize the use of heat transfer surface. Control shall be able to dynamically change the path and coil circuiting based on one of the following operating parameters: head pressure, suction pressure, system sub-cooling requirements, available refrigerant charge, system mode of operation, coil heat transfer efficiency shall have a variable flow path heat exchanger function to vary the refrigerant flow path based on system operating mode and operating conditions.

- a. System inverter compressors shall have a mid-stage, medium pressure vapor economizer apparatus to maximize refrigerant compression efficiency.
- b. System accumulator shall be provided with controls that continuously monitors, modifies, and controls the amount of refrigerant in circulation (active refrigerant charge) while the system is operating. The active refrigerant charge microprocessor shall monitor system high and low side

gas pressure, coil approach temperature, liquid line temperature and pressure, and system sub-cooling requirement to control the refrigerant charge.

- c. System shall comprise of the following frame configurations.

O. Refrigerant Pipe System Design Parameters

- a. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively.
- b. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
- c. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

P. Defrost Operations

- a. The outdoor unit(s) shall be capable of defrost operation to melt accumulated frost, snow and ice that may have accumulated on the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables.
- b. Indoor Unit Fan Operation During Defrost
 - i. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.
 - ii. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.
 - iii. During full system defrost operation, indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

Q. Oil Management

- a. Each outdoor unit shall have an independently operating Hi-POR (High Pressure Oil Return) system to maximize compressor efficiency and ensure a consistent film of oil on all moving compressor parts at all speeds.
- b. The oil return system shall include a dedicated centrifugal oil separator for each compressor designed to extract oil from the oil/refrigerant gas stream leaving the compressor.
- c. Oil collected by each compressor independent oil return system shall be returned directly to the compressor oil sump passively without the use of mechanical pumps or other apparatus
- d. Oil return systems that depend on differential pressure to return oil to the compressor sump, for example bleeding off or bypassing any amount of high pressure gas to push oil back to the compressor sump or the suction inlet of the compressor chamber, shall not be accepted.
- e. Compressor oil shall be maintained at the same temperature as the discharge gas leaving the compressor to prevent any blending of refrigerant and oil to maintain stable oil viscosity during compressor operation.
- f. The oil return system shall not inject, blend, or otherwise mix collected oil with suction vapor refrigerant before entering the compressor scroll or other gas compression apparatus.
- g. The oil return system shall provide an oil level monitor for each compressor that provides continuous feedback to the outdoor unit microprocessor.
- h. The microprocessor shall initiate an oil return cycle when the oil level monitoring sensor indicates a low oil level in the compressor sump.
- i. Timed and/or scheduled unmonitored oil return operations and/or any oil return system that does not initiate an oil return cycle based on compressor sump low level reading shall not be permitted.

R. Cabinet

- a. Outdoor unit cabinet shall be made of 20-gauge galvanized steel with an enamel finish.
- b. Outdoor unit cabinet shall have a heavy gauge coated wire coil guard.

- c. Outdoor unit cabinet finish shall have been tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
- d. All internal serviceable components shall be accessible by removing the front panel of the unit. Outdoor units that require the removal of side and/or rear service panels shall not be permitted.
- e. A controls maintenance and unit diagnostic access port shall be provided in front of the microprocessor to allow quick access to read service codes, set DIP switches, perform microprocessor operational checks, address system components and extract operational data without removing the unit's front panel(s).
- f. The controls access port shall be no larger than 6-1/4" x 6-3/4" to the possibility of weather-related moisture entering the control panel while service is in progress.
- g. A baked galvanized steel access port cover with a baked enamel finish (color matching unit cabinet) shall be provided and easily removed.
- h. Controls access port cover shall be secured to the unit with a factory provided braided steel wire lanyard to prevent loss/damage to the port cover.
- i. The cabinet shall be designed with pre-punched pipe and electrical knockouts. Cabinet shall be designed to accept connection of refrigerant pipe, power cable, and communications wiring either:
 - i. Through the front panel
 - ii. Through the right side
 - iii. Through the unit's base pan (bottom)
- j. Only one fan blade per fan motor shall be accepted. Dual fan assemblies driven by a double-end shaft motor shall not be permitted.
- k. Each fan blade and motor assembly shall be balanced, tested, and mounted to the unit frame using a means of isolation that will eliminate any objectionable audible harmonic or vibration being transferred to the unit frame.

- l. A raised ferrous wire metal guard with a baked enamel finish (color matching unit cabinet) shall be provided to prevent large object and animal contact with moving parts.
- m. The outdoor fan inverter drive shall be provided with a DIP switch that reprograms the DC inverter drive to allow outdoor unit fan assemblies to operate under high discharge static conditions (up to 0.32 in-wg external static pressure) such as a ducted discharge application.

S. Outdoor Unit Coil

- a. Shall be a variable path design.
- b. Shall be provided and built by the VRF outdoor unit provider.
- c. It shall be comprised of aluminum fins mechanically bonded on copper tubing.
- d. The copper tubes shall be internally ribbed to maximize heat transfer. Smooth bore tubes are not acceptable.
- e. The aluminum fin heat transfer surfaces shall be treated to maximize the life of the fin material. Coil fin heat transfer surfaces shall be treated with a factory applied corrosion resistant coating. Coating of fins shall be a two-step process. Base coat shall be an anticorrosive paint specifically engineered for bonding to bare aluminum. The topcoat shall be a Hydrophilic paint with a gloss finish to protect the anti-corrosion coat. Hydrophilic paint shall be specifically formulated to promote liquid precipitation runoff and assist in minimizing particulate debris from sticking to the fin's heat transfer surfaces.
- f. Fin material coating shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
- g. All the outdoor units shall have a minimum of a 3-row heat exchanger.

T. Compressor:

- a. Each 6, 8, 10-ton frames shall be equipped with one hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.
- b. The 12- and 14-ton frames shall be equipped with two hermetically sealed,

inverter-speed controlled scroll compressors.

- c. Outdoor unit frames containing constant speed 50-60 Hz compressor(s) or containing a constant speed 50-60 Hz compressor in combination with an inverter compressor(s) are not acceptable.
- d. Each inverter driven, HSS scroll compressor shall be capable of operating in a frequency range from 15 Hz to 150 Hz with control in 0.5 Hz increments.
- e. Each compressor shall be equipped with a minimum of a 60-Watt crankcase heater.
- f. The compressor shall be provided from the factory with a full charge of Polyvinyl Ether (PVE) oil. Ester based oils are not acceptable (POE) to prevent gum from forming in the system in the case of a motor burn.
- g. All compressor bearing(s) shall have Teflon™ coating.
- h. All compressors shall be protected with:
 - i. High Pressure switch
 - ii. Over-current/under current protection
 - iii. Phase failure
 - iv. Phase reversal

U. Sound Levels

- a. Outdoor unit noise levels shall not exceed 60 dB A. Test protocol includes a sound level measurement taken at an elevation of 5 ft. above the mounting surface at the center point of the width of the outdoor unit frame at a distance of 1 meter in front of the front panel surface with all fans running at absolute maximum motor design speed at all unit operating modes including high heating mode in an anechoic chamber using ISO3745 test standard protocol.

V. Sensors

- a. Each single cabinet shall have:
 - i. Suction temperature sensor

- ii. Discharge temperature sensor
- iii. High Pressure sensor
- iv. Low Pressure sensor
- v. Outdoor temperature sensor
- vi. Outdoor unit heat exchanger temperature sensor

2.4 REFRIGERANT ZONE DISTRIBUTION SYSTEMS

A. General

- a. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
- a) HR unit casing shall be made with galvanized steel and have a galvanized steel finish.
- b) HR unit shall be powered using a 208-230V/1-phase/60Hz power supply.
- c) HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems simultaneous cooling and heating operation.
- d) HR unit shall be engineered to work with a heat recovery piping system, whether it is two-pipe, or three-pipe.
- e) HR unit shall be a multi-port design capable of serving between one and 8 indoor units per HR unit port with a combined cooling nominal capacity of 54 Mbh per IDU port. HR units shall be able to accept/service at least two indoor units per HR unit up to a combined connected IDU cooling capacity of 192 Mbh.
- f) VRF system controller shall be capable of accommodating up to 16 HR units connected to HR units piped in a single series string.
- g) Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
- h) HR unit shall be internally piped, wired, assembled, leak and run tested at

the factory.

- i) HR unit shall be designed for installation in a conditioned environment and provided with factory applied insulation on all cold surfaces.
- j) HR unit shall have a liquid bypass circuit between the high-pressure vapor and the low-pressure vapor pipes.
- k) Each port IDU port shall have a pair (2) two-position solenoid valves.
- l) HR unit shall have a balancing valve to control the pressure between the high pressure and low-pressure pipe during mode switching.
- m) HR unit shall contain a sub-cooler circuit with stand-alone controls for each HR unit.
- n) HR cold surface pipes shall be factory insulated to prevent condensation.
- o) HR unit shall not require a condensate drain. Manufacturer's providing HR models that require a condensate drain line shall reimburse the pipe fitter or others responsible for the portion of the cost associated with the condensate drain system design, parts, and installation.
- p) All field provided refrigerant piping and VRF system refrigerant piping components between outdoor unit and HR unit and from HR unit to indoor unit shall be field insulated.
- q) The HR unit shall not exceed a net unit weight of 49 lbs.

2.5 3-PHASE VRF SYSTEM PIPING CAPABILITIES

A. The elevation differences for heat recovery systems shall be:

- a. Zone Distribution System (HRU) to connected indoor unit shall be 49 feet.
- b. HRU to HRU shall be 49 feet.
- c. Indoor unit to indoor unit connected to same HRU shall be 49 feet.
- d. Indoor unit to indoor unit connected to separate parallel HRU's shall be 131 feet.
- e. The acceptable elevation difference between two series connected HR units shall be 16 feet.

2.6 CONTROLS

- A. System shall be capable of operating in simultaneous heating and cooling modes for all associated connected zones.
- B. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with indoor units and outdoor units over a single stranded, shielded, twisted wire pair.
- C. Manufacturer shall provide screw terminal connections at the HR unit to terminate power wiring and communications cables.
- D. Each VRF system shall be provided with a BAS gateway to building's DDC system, so that it can monitor, communicate, and adjust all alarms, setpoints, overrides, sensor readings, etc., as indicated in Sequence of Operations and Points List on the construction drawings. The BAS gateway must be open protocol to allow future programming and adjustment by the owner, or owner's representative.

2.7 ZONE DUCTED UNIT

- A. The indoor unit shall be a factory-assembled, concealed, fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for hanging above a ceiling in a non-conditioned space. Computerized PID control shall be used to maintain room temperature within 1°F. The unit shall be powered by 208 Volt, 60 Hz, single phase electrical wiring.
- B. Coils shall be direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - a. Refrigerant connections shall be flare connections.
- C. Condensate pan shall be located under the coil.
- D. Fan shall be direct-drive turbo type with statically and dynamically balanced impeller with high and low fans speeds.
 - a. Fan motor shall be thermally protected.
- E. Controls:
 - a. The unit shall be compatible with interfacing with connection to building BMS system.
- F. Filter
 - a. Return air shall be filtered through a min. MERV-6 1" throwaway filter. Provide one set of construction filters and one set of replacement filters. Coordinate filter storage with

owner.

G. Accessories:

- a. Wall-mounted temperature sensor with override, capable of full operation of unit's control sequences.
- b. Spring hangers for vibration isolation
- c. Disconnect switch
- d. Filters
- e. Return plenum
- f. Filter flange
- g. 1" MERV-6 (min.) filter

2.8 ZONE CASSETTE UNIT

- A. The indoor unit shall be a factory-assembled, fan coil unit mounted at ceiling level, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into an ACT or gypsum board ceiling within a conditioned space. Computerized PID control shall be used to maintain room temperature within 1°F. The unit shall be powered by 208 Volt, 60 Hz, single phase electrical wiring.
- B. Coils shall be direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - a. Refrigerant connections shall be flare connections.
- C. Condensate pan shall be located under the coil.
- D. Fan shall be direct-drive turbo type with statically and dynamically balanced impeller with high and low fans speeds.
 - a. Fan motor shall be thermally protected.
- E. Controls:
 - a. The unit shall be compatible with interfacing with connection to building BMS system.
- F. Filter
 - a. Return air shall be filtered by means of a washable long-life filter with mildew proof resin.

- G. The unit shall have knock-out(s) for distributing air via branch ductwork to other areas of the building. Knockouts shall be minimum 6"x4" each. Where multiple ducts are shown from the unit, the unit must have available 6"x4" knockouts for each duct.
- H. Accessories:
 - a. Wall-mounted temperature sensor with override, capable of full operation of unit's control sequences.
 - b. Integral condensate drain pump with a minimum lift of 21".
 - c. Ceiling grille
 - d. Disconnect switch
 - e. Branch duct connections
 - f. filters

2.9 ZONE CEILING SUSPENDED MOUNTED UNIT

- A. The indoor unit shall be a factory-assembled, ceiling suspended-mounted, fan coil unit, operable with R-410A refrigerant, equipped with a electronic expansion valve, for installation onto a ceiling/structure within a conditioned space. Computerized PID control shall be used to maintain room temperature within 1°F. The unit shall be powered by 208 Volt, 60 Hz, single phase electrical wiring.
- B. Coils shall be direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - h. Refrigerant connections shall be flare connections.
- C. Condensate pan shall be located under the coil.
- D. Fan shall be direct-drive turbo type with statically and dynamically balanced impeller with high and low fans speeds.
 - a. Fan motor shall be thermally protected.
- E. Controls:
 - a. The unit shall be compatible with interfacing with connection to building BMS system.
- F. Filter
 - a. Return air shall be filtered by means of a washable long-life filter with mildew proof resin.

G. Accessories:

- a. Wall-mounted temperature sensor with override, capable of full operation of unit's control sequences.
- b. Integral condensate drain pump with a minimum lift of 21".
- c. Applicable mounting hardware
- d. Disconnect switch
- e. filters

2.10 ZONE FLOOR-MOUNTED UNIT

- A. The indoor unit shall be a factory-assembled, floor-mounted, uncased, fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into a constructed cabinet. Computerized PID control shall be used to maintain room temperature within 1°F. The unit shall be powered by 208 Volt, 60 Hz, single phase electrical wiring.
- B. Coils shall be direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - i. Refrigerant connections shall be flare connections.
- C. Condensate pan shall be located under the coil.
- D. Fan shall be direct-drive turbo type with statically and dynamically balanced impeller with high and low fans speeds.
 - a. Fan motor shall be thermally protected.
- E. Controls:
 - a. The unit shall be compatible with interfacing with connection to building BMS system.
- F. Filter
 - a. Return air shall be filtered through a min. MERV-6 1" throwaway filter.
- G. Accessories:
 - a. Return-air mounted temperature sensor, capable of allowing control from a "master" remote thermostat.
 - b. Supply duct flange and extension

- c. Disconnect switch

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- B. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- C. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1.2 CONNECTIONS

- A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- B. Connect supply and return condenser connections with shut off-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- C. Install piping adjacent to unit to allow service and maintenance.

1.3 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 connection, and to assist in field testing. Report results in writing.
- B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 5250

SECTION 23 7413 - DEDICATED OUTDOOR AIR UNIT (PACKAGED)

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Packaged outdoor air unit.
- B. Refrigeration components.
- C. Unit operating controls.
- D. Roof curb.
- E. Electrical power connections.
- F. Operation and maintenance service

1.2 RELATED SECTIONS

- A. Section 15170 - Motors.
- B. Section 15242 - Vibration Isolation.
- C. Section 15290 - Ductwork Insulation.
- D. Section 15885 - Air Cleaning.
- E. Section 15952 - Controls and Instrumentation.
- F. Section 16180 - Equipment Wiring Systems.

1.3 REFERENCES

- A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems. (all)ETL Listed and Labeled ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration. (all)
- B. Standard for Safety Heating and Cooling Equipment-Third Edition, UL 1995/CSA C22.2 236-05, dated February 18, 2005, with revisions through July 30, 2009 (all for cooling and for electric heat)
- C. ANSI/ASHRAE/IESNA 90.1-2010 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.
- D. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.
- E. California Energy Commission Administrative Code - Title 20/24 - Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California. (all)

F. ANSI/NFPA 70-1995 - National Electric Code. (all)

G.

1.4 SUBMITTALS

- A. Submit unit performance data including capacity, nominal and operating performance.
- B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
- D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.
- E. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

1.5 DELIVERY, STORAGE and HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.6 WARRANTY

- A. Provide parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- B. Provide five-year extended parts warranty for compressors.
- C. Provide twenty-five-year heat exchanger limited parts warranty.

1.7 REGULATORY REQUIREMENTS

- A. Unit shall conform to the appropriate standards listed in Section 103.
 - 1. In the event the unit is not approved by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the appropriate standards, the manufacturer shall, at manufacturer's expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

1.8 EXTRA MATERIALS

- A. Provide one set of operational filters and set of spare filters.

PART 2 - PRODUCTS

2.1 SUMMARY

- A. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.2 GENERAL UNIT DESCRIPTION

- A. Unit(s) furnished and installed shall be packaged outdoor air unit (s) as scheduled on contract documents and these specifications. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, air filters, supply motors and unit controls.
- B. Before shipment, each unit(s) shall be leak tested, dehydrated, charged with refrigerant (R-410A) and compressor oil, and factory run tested for proper control operation.
- C. For units greater than 30 nominal tons cooling, the condenser coils must be aluminum fin, mechanically bonded to copper tubing. For units 30 tons or less, coil shall have a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds. Coil construction shall consist of aluminum alloys for fins, tubes, and manifolds in combination with a corrosion-resistant coating.
- D. Cabinet construction shall provide access panels for all parts requiring service.
- E. Direct-drive, vertical discharge condenser fans must be provided with built-in thermal overload protection.
- F. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
- G. Unit(s) shall be horizontal airflow as manufactured. Downflow units are not acceptable.
- H. Wiring internal to the unit shall be colored and numbered for identification.

2.3 UNIT CASING

- A. Cabinet: Zinc-coated, heavy gauge, galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be tested 672 hours in a salt spray test in compliance with ASTM B45. Structural members shall be a minimum of 16 gauge with access doors and removable panels of minimum 20 gauge.

B. P

panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.

- C. Insulation: 2" polyisocyanurate Foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
- D. Cabinet construction shall provide access panels for all parts requiring service.
- E. Cabinet top cover shall be one-piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.
- F. Panels: Water- and air-tight hinged panels with handles shall provide access to filters, heating section; optional ERV and power exhaust fan section, supply air fan section, evaporator coil section, and unit control section. Door hardware shall be oriented to allow the door swing to be reversed.
 - 1. Latches with hold down hooks will be factory installed on hinged access doors.
- G. Type 304 Stainless steel drain pan sloped in two directions to ensure positive drainage. Pan shall have a minimum depth of 2". Seams exposed to standing water shall be welded liquid tight. Base of pan shall be insulated with 1" thick foam insulation.
- H. Provide openings either on side of unit or thru the base for power, control connections.
- I. Provide corrosion inhibiting coatings available for the unit exterior, interior and coils. Interior liner 304 stainless with seams sealed with caulk.
- J. Coil Coating: Coil will have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas with no material bridging between fins. The coating process will ensure complete coil encapsulation and a uniform dry film thickness from 0.6 – 1.2 mills on all surface areas including fin edges and meet 5b rating cross hatched adhesion per ASTM B3359- 93. Corrosion durability will be confirmed through testing with no less than 5,000 hours salt spray resistance per ASTM B117-90 using scribed aluminum test school coupons. The coil coating will meet the following test standards:
 - MIL-C-46168 Chemical Agent Resistance – DS2, HCL Gas
 - CIDA-A-52474-A (GSA)
 - MIL-STD810F, Method 509.4 (Sand and Dust)
 - MIL-P-53084 (ME)-TACOM Approval
 - MIL-DTL-12468 Decontamination Agent (STB)
 - DPG (Dugway Proving Grounds) Soil & Water Exposure Tests
 - GM9540P-97 Accelerated Corrosion Test (120 cycles)

- ASTM B117-G85 Modified Salt Spray (Fog) Testing-2,000 hours (tested by ARL for Lockheed Martin)

- K. The unit(s) must comply per above - spray coatings not acceptable
- L. The base of the unit shall have provisions for forklift and crane lifting

2.4 POWER WIRING

- A. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.
- B. Power wiring to be single point connection.
- C. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.
- D. Factory mount and wire unit main power disconnect device overcurrent and SCCA rated for total unit power connection.
- E. Factory installed safety barrier shall isolate all high voltage components, mounted inside electrical compartment, to protect service personnel from incidental contact.
- F. Factory to mount and wire optional 120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

2.5 LOW VOLTAGE CONTROLS

- A. Factory mount and wire 24-volt control system complete with required transformers and fusing.
- B. Main Control Module (MCM) shall prevent simultaneous operation of any modes and shall enable operation in Dehumidification, Cooling, Heating or Economizer mode based on programmed settings for (select one)
 - 1. Space conditions
 - 2. Outdoor air conditions
- C. MCM shall accept separate setpoints for Occupied and Unoccupied states.
- D. MCM shall control based on dew point design settings for Dehumidification and Economizer modes, and sensible temperature settings for heating and cooling modes.
- E. Inducer fan shall be direct drive high pressure centrifugal type and shall
- F. Factory installed and wired sensors shall monitor Outdoor Air (OA) temperature, humidity and evaporator leaving air temperature.
- G. Supply air sensor shall be furnished with unit. Installing contractor shall install remote

mounted supply air sensor in supply air duct and LAN connections to unit.

- H. Rh sensor(s) shall be furnished, and field wired to unit.
- I. Optional modulating hot gas reheat shall be enabled in dehumidification mode with modulation controlled by MCM to maintain (supply air temperature / space temperature).
- J. System controls shall include anti-cycle timing and minimum compressor run/offtimes.
- K. Systems controls shall be digital, programmable type with access via factory installed and wired touchscreen, or through portable computer connection. All setpoints, unit functions, and status shall be accessible via the touchscreen or portable computer.
- L. MCM shall include preprogrammed test modes, engaged thru operator display, that permit operation in dehumidification, cooling, heating, or economizer test modes and facilitate complete start-up of all unit mechanical and control components.
- M. Factory install and wire (return air / supply air) smoke detector(s)
- N. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.
- O. Field wiring of zone controls to be NEC Class II.

2.6 FANS AND MOTORS

- A. Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access.
- B. All fan motors shall meet the U.S. Energy Policy Act of 2005/10 (EPACT).
- C. All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection.
- D. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.
- E. Provide shafts constructed of solid hot rolled steel, ground and polished, with keyway, and protectively coated with lubricating oil.

2.7 ELECTRIC HEAT SECTION

- 1. Unit shall include an electric heating section complete with fuses, and a resettable high temperature limit switch and capacities as shown on the plans.

2.8 EVAPORATOR CONDENSOR AND REHEAT COILS

- A. Evaporator coils shall be constructed of copper tubes mechanically bonded to a configured aluminum plate fin. For units greater than 30 nominal tons cooling, the hot gas reheat coils must be aluminum fin, mechanically bonded to copper tubing. For units 30 tons or less, hot gas reheat coil shall have a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds. Coil construction shall consist of aluminum alloys for fins, tubes, and manifolds in combination with a corrosion-resistant coating.
- B. Coils shall be leak tested at the factory to ensure pressure integrity. The evaporator coil, reheat coil and condenser coil shall be leak tested to 500 psig and pressure tested to 500 psig.
- C. The condenser coil shall have a fin designed for ease of cleaning.
- D. Evaporator coil shall have six interlaced rows for superior sensible and latent cooling.
- E. Reheat coil shall be fully integrated into the supply air and fan system and capable of delivering design supply air temperature.
- F. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated a minimum of six inches.

2.9 REMOTE CONDENSING UNIT

- A. Outdoor Fans: vertical discharge, direct drive fans with polymer blades.
- B. Fans shall be statically balanced.

2.10 REFRIGERANT CAPACITY CONTROL

- A. Units with scroll compressors shall be equipped with Refrigerant Capacity Control (RCC) on the lead circuit to modulate compressor capacity during Dehumidification or Cooling modes to maintain evaporator Dehumidification or Cooling setpoint and prevent evaporator frosting or freezing. RCC shall be (standard mechanical / optional electrical).
- B. The RCC setpoint is factory set, and field adjustable, to maintain desired suction pressure and compressor discharge pressure.
- C. Capacity control for units equipped with digital scroll compressors, or variable speed compressors, shall be accomplished through compressor controls.

2.11 REFRIGERATION SYSTEM

- A. Compressor(s): All units shall have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. The lead compressors shall be fully variable speed.
- B. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
- C. Internal overloads shall be provided with the scroll compressors.
- D. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
- E. Provide each unit with hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports

2.12 BUILDING MANAGEMENT SYSTEM

- A. Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). The only field connection to Energy Management System shall be a single communication link.
- B. Control Functions: Occupied/unoccupied mode, demand limiting,
 - a. conditioning mode set points discharge air set point adjustment, and
 - b. alarm shutdown.
- C. Provide capabilities for Boolean Processing and trend logs as well as
 - a. "templated" reports and logs.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Contractor shall verify that roof is ready to receive work and support frame has been supplied by the structural engineer.
- B. Contractor shall verify that proper power supply adequate to supply the unit.

3.02 INSTALLATION

- A. Contractor shall install in accordance with manufacturer's instructions.
- B. Mount units on steel support rail system. Mount unit level.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Startup must be by a certified factory technician employed by the unit manufacturer. Factory service location must be within a 50-mile radius of the job site.

PART 4 SEQUENCE OF OPERATIONS

4.01 DEDICATED OUTDOOR AIR UNITS (OAU)

- A. Microprocessor controller - Each OAU shall be controlled by a stand-alone microprocessor-based controller with resident control logic. The controller will interface with the BAS and the inputs and outputs in the points list to accomplish the following temperature control and energy conservation strategies.
 - 1. Occupied Mode - All unit functions will be enabled for normal heating and cooling operation. Unit defaults to default temperature setpoints in the unit microprocessor when communication with BAS is lost.
 - 2. Occupied Space Temperature Control - When in occupied mode as described above, the dedicated unit control shall operate stages of heating and cooling to maintain space temperature setpoint. Setpoints may be set by one of the following methods:
 - a. Remotely through BAS by the system operator.
 - b. Locally through the unit ROD; located in the space through the BAS system;
- B. Low Ambient Compressor Lockout - Compressor operation shall be disabled below a user defined outdoor air temperature.
- C. Unit status report - For each OAU unit, the BAS shall provide an operating status summary of all sensed values (zone temperature, discharge temperature, etc.) set points and modes.

END OF SECTION 23 5223

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

1.01 GENERAL

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. All free-standing electrical equipment such as switchboards, motor control centers, transformers, generators, etc., shall be mounted on 4inch housekeeping pads mechanically connected to the structural floor.
- C. Conductors serving two separate power systems (i.e. 120/208 V and 277/480 V) shall not be mixed in the same raceway, pull box, or junction box. Exception is where control wiring is a different voltage than the power.
- D. Conductors feeding lighting outlets shall not be combined in the same raceway with conduit serving convenience receptacles. Lighting outlets and convenience receptacles shall not be connected on the same circuit unless specifically intended.
- E. Boxes and devices installed in suspended ceilings are to be supported to the grid with an independent support wire to structure.
- F. All electrical conductors shall be copper.

1.02 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.
 - 6. Thermographic Imaging.
 - 7. Acoustic treatment where acoustical batt is used.

1.03 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For sleeve seals.

1.05 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. Connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- E. Coordinate acoustical treatments for electrical devices, boxes, conduit, etc. with architectural wall schedule for acoustical details where acoustical batt is present.

PART 2 - PRODUCTS

2.01 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. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

- b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.02 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.02 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. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. 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.
- I. 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."
- J. 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."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.03 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.

3.04 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.05 Thermographic Imaging

- A. Thermographic imaging survey shall be required for the following equipment installations:
 - 1. Medium Voltage Cable terminations.
 - 2. Pad Mount Transformer connections (primary and secondary).
 - 3. Service Entrance Switchboard Connections.
 - 4. Emergency Generator Connections.
 - 5. Automatic Transfer Switch Connections.
- B. The thermographic imaging survey shall be performed by a thermographic imaging contractor who is a level III certified Thermographer and who has received accreditation through a NETA accredited Thermography training program. The imaging contractor shall have an equipment calibration program that is traceable to the National Institute of Standards and Technology (NIST). Imaging equipment must be calibrated within the last six months. Imaging equipment shall include a Forward-Looking InfraRed camera able to detect emitted thermal infrared radiation and convert the detected emissions into a visual image. The imaging contractor shall provide a test report to the engineer and owner. Deficiencies shall be addressed by the Electrical Contractor.

3.06 Required Inspections

- A. It shall be the responsibility of the electrical contractor to notify the Office of the State Electrical Inspector at the State Construction Office to schedule required inspections including rough-in, above ceiling and final inspections.

3.07 INFORMATION MODELING

- A. Electrical contractor shall be responsible for providing the final coordination model (electrical items) to the owner that meets all applicable formatting and documentation requirements as noted in the latest version of the UNC Charlotte bim/vdc requirements implementation plan. Items that shall be provided include but is not limited to input of associated equipment model numbers, serial numbers, tracking data asset tags, etc.

END OF SECTION 26 0500

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General 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, plus the following special applications:
 - 1. Overhead-lines grounding.
 - 2. Underground distribution grounding.
 - 3. Common ground bonding with lightning protection system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
 - 5. Grounding for sensitive electronic equipment.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on NFPA 70B.
 - a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.
- 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 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. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches in cross section, unless otherwise indicated; with insulators.

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 in diameter.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Power and lighting circuits #10 AWG and smaller shall have solid copper conductors. Conductor sizes #8 AWG and larger shall have Class B stranded conductors.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum, or as indicated on the plans.
 - 1. Bury at least 30 inches below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors' level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.

5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- H. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 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. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches 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. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
 - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. 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. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service (Domestic and Fire) 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 Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. 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 apart.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following 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.
 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. 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.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Report measured ground resistances that exceed the following values: Ground resistance shall be tested with a ground resistance tester.
 1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 25 ohms.
 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 25 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 25 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 25 ohm(s).
 5. Substations and Pad-Mounted Equipment: 25 ohms.
 6. Manhole Grounds: 25 ohms.
- D. Upon completion of installation of the electrical grounding and bonding systems, the ground resistance shall be tested with a ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, appropriate action should be taken to reduce the resistance to 25 ohms, or less, by driving additional ground rods. (The compliance should be demonstrated by retesting.)

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Division 26 Section 260548 "Vibration and Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 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 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
- B.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.

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- 6. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- F. Please add to the specifications that conduits installed on the interior of exterior building walls shall be spaced off the wall surface a minimum of ¼-inch using "clamp-backs" or strut.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete (Limited Applications)."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

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 minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

SECTION 26 0533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
- C. Raceways shall be metal except as specifically noted, or where non-metallic raceway is permitted by these specifications. A Green Grounding conductor shall be provided in all conduit except for telecommunications, data and audio conduits.
 - 1. All electrical distribution within buildings shall be installed in rigid, intermediate or EMT conduit utilizing all steel compression type fittings as connectors or couplings.
 - 2. Electric metallic tubing (EMT) is permitted for most other general applications except for:
 - a. Where tubing, couplings, elbows and fittings would be in direct contact with the earth or underground (in/below slab-on-grade or in earth).
 - b. Any location outdoors where the tubing, etc., would be exposed to the elements.
 - c. Where exposed to severe corrosive influence and/or physical damage.
 - 3. Use heavy wall metal conduit (RMC) or intermediate metal conduit (IMC) for any conduit exposed below a height of 60".
- D. Use flexible conduit for appropriate applications. Use galvanized type for dry locations and liquid-tight type for wet locations, or as noted. Flexible conduit shall be minimum 1/2" diameter. Liquid-tight flexible metal conduit shall be used for final connection to all motors, transformers, and other rotating or vibrating equipment. Flexible metal conduit shall be used

for final connection to lighting fixtures mounted in or on suspended ceilings, and similar applications with a maximum of 6' length. MC cable shall NOT be allowed to be used as a wiring method for branch circuits.

- E. Non-metallic raceway shall be minimum Schedule 40 PVC. In general, non-metallic raceway will be permitted for use underground or in poured concrete (including panel feeders, branch circuits, etc.), provided all 90 degree ELLs up out of the floor are heavy wall rigid metal conduit (RMC), no exception. Non-metallic raceways will not be permitted for any exposed work or for raceways in ceiling spaces, etc.
- F. No raceway may be exposed in any finished space unless specifically so approved, in written form, prior to rough-in. Raceways exposed in finished spaces shall be of an appropriate type "wiremold" type surface raceway or approved equal. In the event of an accepted alternate that requires exposed conditions in a finished space, devices and fixtures shall be located to minimize exposure of raceway and maintain all required clearances, coverage, etc. Devices, fixture, etc. shall be positioned aesthetically/orthogonal to the orientation of the room.
- G. Minimum metal conduit size shall be 3/4" (interior) and 1" (exterior) for premises wiring system. Exception shall be 1/2" for switch legs, control circuits, signal wiring and applications for flexible metal conduits not exceeding four circuit conductors.
- H. Where installing conduit on interior surface of exterior walls, mount conduit minimum 1/4 -inch from wall with clamp-backs or strut.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing, not allowed on this project.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. LFNC: Liquidtight flexible nonmetallic conduit, not allowed on this project.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
 - 2. For handholes and boxes for underground wiring, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For professional engineer and testing agency.
- E. Source quality-control test reports.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Allied Tube & Conduit.
 - 2. Western Tube.
 - 3. Wheatland Tube Company.
 - 4. Republic Conduit.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. IMC: ANSI C80.6..5.
- D. PVC-Coated Steel Conduit: PVC-coated IMC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, minimum.
- E. EMT: ANSI C80.3.
- F. FMC: Zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket.
- H. 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: Steel, compression type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

- B. ENT: Not allowed.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: Not allowed.
- E. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Arnco Corporation.
 2. Endot Industries Inc.
 3. IPEX Inc.
 4. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 12, unless otherwise indicated.

- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized metallic with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman.
 - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 - 6. O-Z/Gedney; a unit of General Signal.
 - 7. RACO; a Hubbell Company.
 - 8. Robroy Industries, Inc.; Enclosure Division.
 - 9. Scott Fetzer Co.; Adalet Division.
 - 10. Spring City Electrical Manufacturing Company.
 - 11. Thomas & Betts Corporation.
 - 12. Walker Systems, Inc.; Wiremold Company (The).
 - 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- 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. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

- E. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.
- F. Nonmetallic Floor Boxes: Nonadjustable, round.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- I. 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.
 - 2. Nonmetallic Enclosures: Plastic.
- J. Cabinets:
 - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. Description: Comply with SCTE 77.
 - 1. Color of Frame and Cover: See drawings.
 - 2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
 - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 5. Cover Legend: Molded lettering, as indicated for each service.
 - 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - 7. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.
 - C. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
 - D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.
- 2.8 SLEEVES FOR RACEWAYS
- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
 - B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 - C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
 - D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.9 SLEEVE SEALS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.10 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by a independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION

- A. Underground runs, except under concrete floor slabs, shall have a minimum of 24" cover. Backfill shall be made in 6" layers – tamping each layer to a density of 95% of maximum possible.
- B. Raceways run external to building foundation walls, with the exception of branch circuit raceways, shall be encased with a minimum of 3" of concrete on all sides. Encased raceways

shall have a minimum cover of 18", except for raceways containing circuits with voltages above 600 volts, which shall have a minimum cover of 30".

- C. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6" to 8" below finished grade. Tape shall be permanent, bright colored, continuous printed, metal compounded for direct burial not less than 6" wide and 4 mils thick. Printed legend on tape shall indicate general type of underground line below.
- D. Red dye shall be applied to the top of freshly placed concrete in all underground high voltage (> 5KV) duct banks as a warning of electrical hazard in the event of future excavation. This is in addition to the required warning tape installed 6" below grade.

3.2 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit
 - 2. Concealed Conduit, Aboveground: IMC (including elbows that turn up from below grade).
Underground Conduit: RNC, Type EPC- 80-PVC, encased in concrete. However, all ducts leaving a building shall be galvanized rigid steel for a minimum distance of five (5) feet from the building.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
 - 5. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
 - c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
- B. Comply with the following indoor applications, unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

- c. Mechanical rooms.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 6. Damp or Wet Locations: IMC.
 - 7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
 - 8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
 - 9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
 - 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

3.3 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
 - 1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

- a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations not subject to severe physical damage.
- P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
- Q. Set metal floor boxes level and flush with finished floor surface.
- R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- S. Conduit and fittings shall be concealed wherever possible especially in finished spaces and public areas. Conduit can be installed exposed in rooms like mechanical, storage etc. however they must be installed in a manner as to be protected from physical damage. Run exposed conduits neatly and as inconspicuously as practicable and install parallel or perpendicular to walls, structural members or intersections of vertical planes and ceilings. Right angle turns may be made with manufactured elbows for sizes of conduit 1-1/4 inches and larger.

3.4 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 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 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 duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. **Ducts should be securely anchored during concrete placement to prevent movement. The required**
6. spacing between adjacent ducts shall be maintained with plastic spacers.
7. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
8. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6 to 8 inches below finished grade. Tape shall be permanent, bright-colored, continuous printed, plastic tape compounded for direct burial not less than 6 inches wide and 4 mils thick. Printed legend shall be indicative of general type of underground line below.

3.5 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- 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. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. 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.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.7 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.8 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."

3.9 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533

SECTION 26 0543-UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
 - 2. Handholes and boxes.
 - 3. Manholes.

1.3 DEFINITION

- A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Accessories for manholes, handholes, boxes, and other utility structures.
 - 4. Warning tape.
- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Reinforcement details.
 - 3. Frame and cover design and manhole frame support rings.
 - 4. Ladder details.
 - 5. Grounding details.
 - 6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - 7. Joint details.

- C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Cover design.
 - 3. Grounding details.
 - 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
- D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- E. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- F. Qualification Data: For professional engineer and testing agency.
- G. Source quality-control test reports.
- H. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- B. Comply with ANSI C2.
- C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

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

1.8 COORDINATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.9 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.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. ARNCO Corp.

2. Beck Manufacturing.
 3. Cantex, Inc.
 4. CertainTeed Corp.; Pipe & Plastics Group.
 5. Condux International, Inc.
 6. ElecSys, Inc.
 7. Electri-Flex Company.
 8. IPEX Inc.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Manhattan/CDT; a division of Cable Design Technologies.
 11. Spiraduct/AFC Cable Systems, Inc.
- B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-80-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- C. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

2.3 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carder Concrete Products.
 2. Christy Concrete Products.
 3. Elmhurst-Chicago Stone Co.
 4. Oldcastle Precast Group.
 5. Riverton Concrete Products; a division of Cretex Companies, Inc.
 6. Utility Concrete Products, LLC.
 7. Utility Vault Co.
 8. Wausau Tile, Inc.
- B. Comply with ASTM C 858 for design and manufacturing processes.
- C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

- a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC." Or "TELEPHONE." As indicated for each service.
7. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Extension shall provide increased depth of 12 inches.
 - b. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
10. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
11. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Description: Comply with SCTE 77.
 1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC." Or "TELEPHONE." As indicated for each service.

6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.
- C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.
- E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Carson Industries LLC.
 - b. Nordic Fiberglass, Inc.
 - c. PenCell Plastics.

2.5 MANHOLES AND VAULTS

- A. Underground structures shall be poured in place or may be of precast construction. Horizontal concrete surface of floors shall have a smooth trowel finish. Concrete shall be cured by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C 309. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Casting shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary lugs, rabbets and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. The words "electric" and "telephone" shall be cast in the top face of all power and telephone manhole covers, respectively.
- B. Medium Voltage Switch vaults shall have spring assist lids for access to termination and switching compartments.
- C. Optional Precast Concrete Construction: In lieu of poured-in-place concrete manholes and hand holds, the Contractor may, at his option, provide precast concrete structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes and handholds.
- D. General: Precast concrete structures shall have the same accessories and facilities as required for poured-in-place structures. Likewise, they shall have plan area and clear heights not less than those of poured-in-place structures. Concrete materials and methods of construction shall be the same as for poured-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 4000 pounds per square inch. Structures may be precast to the design and details shown for poured-in-place construction, precast monolithically and placed as a unit; or, they may be of assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. All structures shall be identified with the manufacturer's name embedded in, or otherwise permanently attached to, an interior wall face.
- E. Structure top and bottom shall be designed for full dead, superimposed dead and live load including impact. Structure sidewalls shall be designed for lateral earth and hydrostatic pressures plus live load (H2O Truck) adjacent to structure. Tops and walls of structures shall be designed for AASHTO standard H20 highway loading, with 30 percent loading added for impact and with design load being that which produces maximum shear and moment. All dead and live loads, as well as impact loading, shall be considered in design. Walls shall be designed to withstand all soil pressures, taking into consideration the soil to be encountered and ground

water level present at the site and assuming that the H2O design vehicle will operate on surfaces adjacent to the structure. Ground water level shall be assumed to be three feet below ground surface unless a higher water table is indicated in the boring logs. Design shall also take into consideration stresses induced in handling units. Lifting devices shall be provided for properly handling units. Calculations and shop drawings shall be submitted covering the design and manufacture of precast units and shall bear the seal of registered professional engineer.

- F. Joints: Mating edges of precast components shall be provided with tongue and grooved joints. Joints shall be designed to firmly interlock adjoining components and to provide waterproof junctions. Joints shall be sealed watertight using preformed plastic strip conforming to AASHTO M 198, Type B. Sealing material shall be installed in strict accordance with the sealant manufacturer's printed instructions. Provisions shall be made for waterproofing cable entrances into structures and at covers in the top slab.
- G. Pulling-in irons shall be steel bars bent as indicated on drawings, and cast in the walls and floors. In the floor they shall be centered under the cover, and in the wall they shall be not less than 6 inches above or below, and opposite the conduits entering the structure. Pulling-in irons shall be projected into the structure approximately 4 inches. Irons shall be zinc-coated after fabrication.
- H. Cable racks, including arms shall be made from 50% glass-reinforced nylon or a non-metallic material having equal mechanical strength, thermal resistance, chemical resistance and dielectric physical properties. Cable racks, including rack arms and insulators, shall be sufficient to accommodate the cables. Racks in power manholes shall be spaced not more than 3 feet apart and each manhole wall shall be provided with a minimum of 2 racks.
 - 1. Provide stainless steel hardware for mounting fasteners. Coat threads of anchor bolts with anti-seize compound immediately prior to installing nuts.
 - 2. Rack arms shall be 8", removable type, and rated capable of supporting 450 lbs working load and 1,000 lbs short term rated.
 - 3. Rack arms shall have slots or holes for securing cables with non-metallic cable wire ties.
- I. Precast Manhole/Vault Installation: Commercial precast assembly shall be set on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to one-inch size extending 12 inches beyond the manhole on each side. Granular fill shall be compacted by a minimum of four passes with a plate type vibrator. Drain sumps shall be provided for all precast structures.
- J. Coordinate requirement for sump pumps in manholes and vaults with Project Manager.
- K. Install 1/0 bars copper ground conduct around inside perimeter of manhole. Connect to 3/4" x 10' - 0" ground rod inside manhole. Bond with #6 bare copper from ring to manhole cover frame, sump covers, etc.

- L. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carder Concrete Products.
 - 2. Christy Concrete Products.
 - 3. Elmhurst-Chicago Stone Co.
 - 4. Oldcastle Precast Group.
 - 5. Riverton Concrete Products; a division of Cretex Companies, Inc.
 - 6. Utility Concrete Products, LLC.
 - 7. Utility Vault Co.
 - 8. Wausau Tile, Inc.
- M. Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
 - 1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
 - 2. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
- N. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.
- O. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.6 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-Place Concrete."
- C. Structural Design Loading: As specified in Part 3 "Underground Enclosure Application" Article.

2.7 UTILITY STRUCTURE ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bilco Company (The).
 2. Campbell Foundry Company.
 3. Carder Concrete Products.
 4. Christy Concrete Products.
 5. East Jordan Iron Works, Inc.
 6. Elmhurst-Chicago Stone Co.
 7. McKinley Iron Works, Inc.
 8. Neenah Foundry Company.
 9. NewBasis.
 10. Oldcastle Precast Group.
 11. Osburn Associates, Inc.
 12. Pennsylvania Insert Corporation.
 13. Riverton Concrete Products; a division of Cretex Companies, Inc..
 14. Strongwell Corporation; Lenoir City Division.
 15. Underground Devices, Inc.
 16. Utility Concrete Products, LLC.
 17. Utility Vault Co.
 18. Wausau Tile, Inc.
- B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 26 inches.
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - c. Legend: "SIGNAL" for communications, data, and telephone duct systems.
 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
- C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, and 1-by-4-inch bolt.
1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

- E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- diameter eye, rated 2500-lbf minimum tension.
- F. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 - 1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
 - 1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- I. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
 - 1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
 - 2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
 - 3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- J. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 - 1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of 9 holes for arm attachment.
 - 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.
- K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

- M. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. One required.
- N. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by a independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

2.9 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by a independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank, unless otherwise indicated.
- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank, unless otherwise indicated.

- C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.
- D. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.
- E. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.
- F. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, installed in direct-buried duct bank, unless otherwise indicated.
- G. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.
- H. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type 40-PVC, in concrete-encased duct bank, unless otherwise indicated.
- I. Underground Ducts Crossing Paved Paths Walks and Driveways Roadways and Railroads: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.2 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
- B. Manholes: Precast or cast-in-place concrete.
 - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.3 EARTHWORK

- A. Excavation and Backfill: Comply with Division 22 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turfs and Grasses" and "Plants."
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.4 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches 12.5 feet 25 feet, both horizontally and vertically, at other locations, unless otherwise indicated.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical/Common Work Results for Communications/Common Work Results for Electronic Safety and Security."
- F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- G. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.

- H. Concrete-Encased Ducts: Support ducts on duct separators.
1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
 3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
 4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
 7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
 8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
 9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
 10. Underground Identification: All underground piping and utilities (both metallic and non-metallic), except copper pipe, shall have a separate copper tracer wire and non-metallic warning tape installed above the utility line.

A. The tracer wire shall be traced for continuity prior to backfill, immediately upon completion of backfill and compaction and once again during final utility location/as built at the end of the project. This also will include landscape irrigation mains to the points of the valves. All above ground utility features such as vaults, manholes, valves, handholds, etc to be properly labeled. Contractor shall provide an inventory of all installed outdoor utility features including type and model.

B. IDENTIFICATION TAPE: The 1st stage of identification shall be a buried warning tape. This tape shall provide an early warning at shallow depth excavation. The tape shall be 6" wide and buried approximately 18" to 30" above the service pipe, but a minimum of 10" below finished grade. It shall consist of multiple layers of polyethylene with an overall thickness of 3 to 5 mils. It shall be installed continuous from valve box to valve box or manhole to manhole and shall terminate just outside of valve box or manhole wall. The black colored lettering on the warning tape shall be abrasion resistant and be imprinted on a color-coded background that conforms to APWA color code standards. The lettering on the tape should name the utility it is protecting (i.e. Caution buried sewer line below).

C. TRACER WIRE: The 2nd stage of identification shall be a buried tracer wire. This tracer wire shall provide pipeline identification, be fully detectable from above grade utility locators, and be able to provide a depth reference point to top of pipe.

D. All pipe, including lawn irrigation lines, and metallic pipe with compression gasket fittings installed underground shall have a tracer wire installed along the length of the pipe. The wire shall be taped to the top of the pipe at a maximum of 10' intervals and not allowed to "float freely" within the backfill.

E. Tracer wire shall be single-conductor, 12 gauge minimum, copper single-conductor wire with type "UF" (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box. A #12 AWG or heavier (smaller AWG number), solid, insulated (RHW, THW, or polyethylene insulation is recommended); copper wire shall be taped to pipe at 10-foot intervals. Do not wrap wire around pipe. The wire must be one continuous, unbroken length. Coil tracer wire at meter location and street end with enough wire to extend a minimum of two feet above grade.

11.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 22 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Division 22 Section "Earth Moving."

5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 22 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. Underground Identification: All underground piping and utilities (both metallic and non-metallic), except copper pipe, shall have a separate copper tracer wire and non-metallic warning tape installed above the utility line.
 - A. The tracer wire shall be traced for continuity prior to backfill, immediately upon completion of backfill and compaction and once again during final utility location/as built at the end of the project. This also will include landscape irrigation mains to the points of the valves. All above ground utility features such as vaults, manholes, valves, handholds, etc to be properly labeled. Contractor shall provide an inventory of all installed outdoor utility features including type and model.
 - B. IDENTIFICATION TAPE: The 1st stage of identification shall be a buried warning tape. This tape shall provide an early warning at shallow depth excavation. The tape shall be 6" wide and buried approximately 18" to 30" above the service pipe, but a minimum of 10" below finished grade. It shall consist of multiple layers of polyethylene with an overall thickness of 3 to 5 mils. It shall be installed continuous from valve box to valve box or manhole to manhole and shall terminate just outside of valve box or manhole wall. The black colored lettering on the warning tape shall be abrasion resistant and be imprinted on a color-coded background that conforms to APWA color code standards. The lettering on the tape should name the utility it is protecting (i.e. Caution buried sewer line below).
 - C. TRACER WIRE: The 2nd stage of identification shall be a buried tracer wire. This tracer wire shall provide pipeline identification, be fully detectable from above grade utility locators, and be able to provide a depth reference point to top of pipe.

D. All pipe, including lawn irrigation lines, and metallic pipe with compression gasket fittings installed underground shall have a tracer wire installed along the length of the pipe. The wire shall be taped to the top of the pipe at a maximum of 10' intervals and not allowed to "float freely" within the backfill.

E. Tracer wire shall be single-conductor, 12 gauge minimum, copper single-conductor wire with type "UF" (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box. A #12 AWG or heavier (smaller AWG number), solid, insulated (RHW, THW, or polyethylene insulation is recommended); copper wire shall be taped to pipe at 10-foot intervals. Do not wrap wire around pipe. The wire must be one continuous, unbroken length. Coil tracer wire at meter location and street end with enough wire to extend a minimum of two feet above grade.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.
2. Install units' level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below the frost line, 12" below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.

2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section "Thermoplastic Sheet Waterproofing." After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
 - G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing." After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
 - H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
 - I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
 - J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
 - K. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.
- 3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE
- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
 - B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
 - C. Elevation: In paved areas and traffic ways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.
 - D. Install handholes and boxes with bottom below the frost line, 12" below grade.

- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi, 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep.

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. After the duct line has been completed, a mandrel not less than 12 inches long, having across section approximately one-fourth inch less than the inside cross section of the conduit shall be pulled through each conduit after which a brush with stiff bristles shall be pulled through to make certain that no particles of earth, sand, or gravel have been left in the lines.
 - 3.
 - 4. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 0543

SECTION 26 0548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Spring isolators.
 - 3. Restrained spring isolators.
 - 4. Channel support systems.
 - 5. Restraint cables.
 - 6. Hanger rod stiffeners.
 - 7. Anchorage bushings and washers.
- B. Related Sections include the following:
 - 1. Division 26 Section "Hangers and Supports For Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: I
 - a. Component Importance Factor: 1.25
 - b. Component Response Modification Factor:
 - c. Component Amplification Factor:
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second):
 - 4. Design Spectral Response Acceleration at 1.0-Second Period:

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 - 3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer, **Licensed in North Carolina**, responsible for their preparation.
 - 1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
 - 2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
 - 3. Field-fabricated supports.
 - 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Preapproval and Evaluation Documentation: an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Welding certificates.
- E. Qualification Data: For professional engineer and testing agency.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.
 - 7. Vibration Eliminator Co., Inc.
 - 8. Vibration Isolation.
 - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene rubber hermetically sealed compressed fiberglass.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Cooper B-Line, Inc.; a division of Cooper Industries.
 4. Hilti Inc.
 5. Loos & Co.; Seismic Earthquake Division.
 6. Mason Industries.
 7. TOLCO Incorporated; a brand of NIBCO INC.
 8. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES OSHPD an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchors and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot dip galvanize metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATIONS

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
 - 1. Install restrained isolators on electrical equipment.
 - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- D. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are

encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

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

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 0548

SECTION 26 0553-IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate. Identification shall be by tags with string or wire attached to conduit or outlet.
- B. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match the surface color scheme outlined below (2.6A). This includes covers on boxes above lift-out and other type accessible ceilings.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.
- E. Write-On Tags: Polyester tag, 0.010-inch-thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 1. Not less than 6 inches wide by 4 mils thick.
 2. Compounded for permanent direct-burial service.
 3. Embedded continuous metallic strip or core.
 4. Printed legend shall indicate type of underground line.
- B. Red dye shall be applied to the top of freshly placed concrete in all underground high voltage (> 5KV) duct banks as a warning of electrical hazard in the event of future excavation. This is in addition to the required warning tape installed 6" below grade.

2.4 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.
- E. Warning label and sign shall include, but are not limited to, the following legends:
 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
 3. Provide "ARC FLASH" warning labels on all switchboards, power panels, enclosed circuit breakers, ATS and other equipment where this hazard exists, as per NEC 110.16

2.5 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch-thick for signs up to 20 sq. in. and 1/8-inch-thick for larger sizes.
1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

- A. Furnish and install engraved laminated phenolic nameplates for all safety switches, panelboards, and other electrical equipment supplied for the project for identification. Nameplates shall be securely attached to equipment with self-tapping stainless-steel screws; if the screw sharp end is protected; otherwise, rivets shall be used. Letters shall be approximately 1/2-inch-high minimum. Embossed, self-adhesive plastic tape is not acceptable for marking equipment. Nameplate material colors shall be:
- Blue surface with white core for 120/208-volt equipment
 - Black surface with white core for 277/480-volt equipment
 - Bright red surface with white core for all equipment related to fire alarm system.
 - Dark red (burgundy) surface with white core for all equipment related to security.
 - Green surface with white core for all equipment related to "emergency" systems.
 - Orange surface with white core for all equipment related to telephone systems.
 - Brown surface with white core for all equipment related to data systems.
 - White surface with black core for all equipment related to paging systems.
 - Purple surface with white core for all equipment related to TV systems.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength: 50 lb, minimum.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):

- a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior concrete and masonry primer.
 - 2) Finish Coats: Exterior semigloss acrylic enamel.
2. Exterior Concrete Unit Masonry:
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Exterior semigloss acrylic enamel.
3. Exterior Ferrous Metal:
 - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior ferrous-metal primer.
 - 2) Finish Coats: Exterior semigloss alkyd enamel.
4. Exterior Zinc-Coated Metal (except Raceways):
 - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Exterior zinc-coated metal primer.
 - 2) Finish Coats: Exterior semigloss alkyd enamel.
5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
 - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior concrete and masonry primer.
 - 2) Finish Coats: Interior semigloss alkyd enamel.
6. Interior Concrete Unit Masonry:
 - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a block filler.
 - 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
7. Interior Gypsum Board:
 - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior gypsum board primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.

8. Interior Ferrous Metal:
 - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior ferrous-metal primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
9. Interior Zinc-Coated Metal (except Raceways):
 - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior zinc-coated metal primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws

PART 3 - EXECUTION

3.1 APPLICATION

- A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
 1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 100A: Identify with orange self-adhesive vinyl label.
- D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands: Unless there is standard campus-wide color code, use the following Nameplate material colors shall be as follows:

Blue surface with white core for 120/208-volt equipment.

Black surface with white core for 277/480-volt equipment.
Bright red surface with white core for all equipment related to fire alarm system.
Dark red (burgundy) surface with white core for all equipment related to security.
Green surface with white core for all equipment related to "emergency" systems.
Orange surface with white core for all equipment related to telephone systems.
Brown surface with white core for all equipment related to data systems.
White surface with black core for all equipment related to paging systems.
Purple surface with white core for all equipment related to TV systems.

- E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use metal tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
- F. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.
- G. Receptacle and Light switch covers: Clear adhesive labels, with black lettering, to be attached to the cover indicating circuit number.
- H. Junction boxes: All junction boxes, that are located above ceilings, are to have a painted cover. Paint color is to indicate what system is contained in the junction box. The cover is to indicate circuit numbers, for junction boxes that contain power conductors, black marker is acceptable for circuit numbers. Additionally, conductors inside the junction boxes need to be labeled with circuit numbers using self-adhesive labels.
- I. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

- L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
 - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 - 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- M. Instruction Signs:
 - 1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 - 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer or load shedding.
- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Labeling Instructions: In Accordance with paragraph 3.1.D:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - 2. Equipment to Be Labeled:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Transformers.

- e. Electrical substations.
- f. Emergency system boxes and enclosures.
- g. Junction box covers (painted)
- h. Receptacle and light switch covers
- i. Motor-control centers.
- j. Disconnect switches.
- k. Enclosed circuit breakers.
- l. Motor starters.
- m. Push-button stations.
- n. Power transfer equipment.
- o. Contactors.
- p. Remote-controlled switches, dimmer modules, and control devices.
- q. Battery inverter units.
- r. Battery racks.
- s. Power-generating units.
- t. Voice and data cable terminal equipment.
- u. Master clock and program equipment.
- v. Intercommunication and call system master and staff stations.
- w. Television/audio components, racks, and controls.
- x. Fire-alarm control panel and annunciators.
- y. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
- z. Monitoring and control equipment.
- aa. Uninterruptible power supply equipment.
- bb. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact,

side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White
 - e. Ground: Green
 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Grey
 - e. Ground: Green
 4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- J. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 26 0553

SECTION 26 08 00 – COMMISSIONING - ELECTRICAL

PART 1 - GENERAL

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, system calibration, testing adjusting and balancing, performance testing and training.

MEP commissioning for this project shall be provided to fulfill the requirements of Section C408 of the North Carolina Energy Conservation Code and NC General Statute 143-135.35-.40 (SB 668). The process structure is based on ASHRAE Guideline 0-2013, ASHRAE Guideline 1.1-2007, ASHRAE Guideline 202-2013 and practices by the NEBB Commissioning Standard.

- A. Review the Owner's Project Requirements (OPR) and design team's Basis of Design (BOD) for clarity and completeness.
- B. Develop commissioning requirements to be included in the construction documents.
- C. Perform a commissioning design review of the design documents and back-check the review comments prior to submission.
- D. Develop and implement the commissioning plan.
- E. Review contractor submittals applicable to systems being commissioned for compliance with the OPR, OBD and design documents.
- F. Verify applicable equipment and systems are installed properly and receive adequate operational checkout by installing contractors.
- G. Verify and document proper performance of plumbing systems.
- H. Assist in review of O&M manuals and warranties.
- I. Develop a Systems Manual to provide future operating staff the information needed to understand and optimally operate the commissioned systems.
- J. Coordinate and verify that the Owner's operating personnel are adequately trained.
- K. Provide a summary of the commissioning activities and submit a commissioning report.
- L. Perform seasonal testing and a review of commissioned systems within the first 10-months after substantial completion.

ABBREVIATIONS

The following are common abbreviations used in the Specifications.

Cx	Commissioning
CxA	Commissioning Authority
PM	Project Manager (Owner)
A/E	Architect and Design Engineers
GC	General / Prime Contractor
EC	Electrical Contractor
PC	Plumbing Contractor
MC	Mechanical Contractor
CC	Controls Contractor
Subs	Subcontractors to General
TAB	Test and Balance Contractor
PFC	Prefunctional Checklist
FPT	Function Performance Test
Cx Plan	Commissioning Plan Document

RELATED SECTIONS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01, 22, 23 and 26 Specification Sections, apply to this section.

COMMISSIONING TEAM

- A. The members of the commissioning team consist of the Commissioning authority (CxA), the Owner Project Manager (PM), the General / prime contractor (GC), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Plumbing Contractor (PC), the Test and Balance Contractor (TAB), the Controls Contractor (CC), any other installing Subcontractors or suppliers of equipment. Additionally, if desires, the facility plant operator/engineer is also a member of the commissioning team. Representative from the A/E team may also be invited to observe critical procedures.
- B. The Contractor shall, through the GC provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Agent in demonstrating prefunctional and functional tests as they relate to each system and their technical specialty.
- C. The Commissioning Agent reserves the right to approve the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include knowledge relative to the specific equipment involved, adequate documentation, tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Agent to get the job done.

MANAGEMENT

- A. The CxA directs and coordinates the commissioning activities and the reports to the Owner. All members work together to fulfill their responsibilities and fulfill the objectives of the Contract Documents.

SCHEDULING

- A. The CxA will work with the GC to project an initial commissioning schedule. The GC will integrate the tentative commissioning schedule into the master schedule. All parties shall address scheduling problems and make necessary notification in a timely manner to avoid delaying the commissioning process. The GC will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.
- B. Functional testing will not begin until the CxA is notified in writing, by the GC that all prefunctional checklists, including startup and TAB work have been completed; and the subcontractors punch work is complete and the systems have been tested completely.
- C. The CxA will have 7 business days to review prefunctional documentation for completeness. If it is determined that the prefunctional and TAB report has not been completed and it impacts the original schedule coordinated by the CxA and GC; the schedule will be revised to include the additional days taken for the contractor to properly complete their work and the CxA to review the document.
- D. As construction progresses, more detailed schedules will be developed by the CxA and GC.
- E. Commissioning is required to be scheduled and completed prior to Substantial Completion.

COMMISSIONING PROCESS DURING CONSTRUCTION

The following narrative provides a brief overview of the commissioning tasks during construction and the general order in which they occur:

- A. Commissioning begins with a Cx kickoff meeting conducted by the CxA where the commissioning process, including Cx Plan is reviewed with the commissioning team members.
- B. Additional meetings will be required throughout construction, scheduled by the PM, CxA & GC with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
- C. Energy related equipment documentation is submitted to the CxA during the normal submittal process for review, after approval by the A/E, including start-up procedures.
- D. The CxA works with the Subs to detail start-up procedures, including providing the Subs with prefunctional checklists (PFC's) to be completed during the startup process.
- E. The TAB contractor submits their TAB plan, for approval by the CxA prior to starting TAB work.
- F. The CxA will review reports from independent testing agencies and A/E reports from on-site periodic construction observation to maintain cohesiveness with project activities.

- G. The CxA will perform site visits and document the progress of the work. An Issues / Deficiency log will be developed to track installation and coordination issues which would affect commissioning and Owner maintenance.
- H. The Subs, under their own direction, execute and document the prefunctional checklists (PFC's), including start-up and initial checkout. The CxA documents that the checklists and start-ups were completed by the Subs according to the approved plans. This will include the CxA witnessing start-up of selected (major) equipment.
- I. The CxA develops specific equipment and system functional performance test (FPT) procedures. The procedures are developed using approved shop drawings and O&M documentation supplied by the contractors.
- J. Under direction of the CxA, functional performance tests (FPT's) are executed by the appropriate sub-contractors. The results of the FPT's are documented by the CxA.
- K. With support from the TAB and CC contractors, the CxA will verify the values reported in the final TAB report.
- L. During prefunctional checkout and functional performance testing, items of non-compliance in material, installation or setup shall be corrected at the Sub's expense and the system retested.
- M. The CxA reviews the O&M documentation for completeness.
- N. The CxA coordinates and verifies training of Owner staff by vendors and sub-contractors.
- O. Deferred / seasonal / warranty testing is conducted with assistance by the appropriate Sub-contractors.

SUBMITTALS

The GC will provide the CxA a copy of the following items, for the systems to be commissioned:

- A. Construction Schedule (initial and all updates)
- B. Construction Progress Meeting Minutes (all meetings)
- C. Approved shop drawings, materials certifications and systems data for energy related systems. Approval review comments by the A/E and any resubmittal required by the A/E shall be copied to the CxA.
- D. One set of approved coordination drawings either electronic media or hard copy which includes all commissioned systems e.g. mechanical, electrical and plumbing.
- E. Piping – Plumbing contractor shall supply one copy of the piping systems pressure test results and one copy of the flushing and clean out report.

- F. Chlorination Report - Plumbing contractor shall supply one copy of the domestic water chlorination report approved by the authority having jurisdiction.
- G. Subs shall submit start-up and initial checkout plan for each piece of equipment / system as recommended by the manufacturer.
- H. Prefunctional checklist (Engineering Point-to-Point Checklist) for controls and energy related equipment as required by this specification.
- I. Operational and maintenance documentation for FPT development.

SYSTEMS TO BE COMMISSIONED

- a. Lighting Controls
- b. Power distribution (utility – switchboard – distribution panels)
- c. Equipment power services (breakers – wiring)
- d. Emergency power (generator – transfer switch)
- e. Power metering
- f. Exterior lighting

PART 2 - PRODUCTS

TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested.
- B. All testing equipment used by the contractors shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.

PART 3 - EXECUTION

The following procedures apply to all equipment to be commissioned. This work is to be performed by the contractor or sub-contractor prior to Functional Performance Testing by the Commissioning Team.

GENERAL

- A. Cooperate with the Commissioning Authority in the following manner:

1. Provide and install balancing cocks, access doors, test ports and P&T ports as required by the CxA, A/E and the Owner for functional testing.
2. Allow sufficient time before final completion dates so that functional testing can be accomplished.
3. Provide labor and material to make corrections when required without undue delay.

MEETINGS

- A. Prior to the start of MEP construction, the A/E, PM, CxA, and GC shall schedule, plan and conduct a commissioning kickoff meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CxA.
- B. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular subs.

START-UP AND INITIAL CHECKOUT

- A. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- B. The CxA will develop prefunctional checklists with the Contractor which indicates the required procedures to be executed as part of startup and initial checkout of the systems. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form.
- C. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
- D. The full start-up plan shall consist of:
 1. The CxA's prefunctional checklists.
 2. The manufacturer's standard written start-up procedures copied from the installation manuals with contractor sign-off.

SENSOR AND ACTUATOR CHECKOUT AND CALIBRATION

- A. All field-installed instrumentation sensors shall be calibrated. All test instruments shall have had a certified calibration within the last 12 months.
- B. Calibrate each instrumentation device by making a comparison between the display and the reading at the device, using an instrument traceable to the National Institute of Standards and Technology, which shall be at least twice as accurate as the device to be calibrated, (e.g., if field device is +/- 0.5% accurate, test equipment shall be +/- 0.25% accurate over same range). Record the measured value and displayed value for each device in the prefunctional checklist.

CONTROL SYSTEM

- A. Check each physical output control point by making a comparison between the control command at the main system and the status of the controlled device. Check each physical output control point by making a comparison of the actual state of the device and the operator workstation graphical representation of the point condition. Record the results for each device in the Prefunctional checklist.
- B. Verify proper sequences by using the approved checklists to record results and submit the Pre-functional checklist. Verify proper sequence and operation of all specified functions.

EXECUTION OF PREFUNCTIONAL CHECKLISTS AND STARTUP

- A. Thirty (30) days prior to startup, the Subs and vendors schedule startup and checkout with the PM, GC and CxA. The execution of prefunctional checklists, startup and checkout is by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
 - 1. The Subs and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists, plus the final TAB report for all equipment and systems.
 - 2. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off.

DEFICIENCIES, NON-CONFORMANCE AND APPROVAL IN CHECKLISTS AND STARTUP

- A. The Subs (including the TAB contractor) shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the CxA within 1-week of test completion.
- B. The CxA reviews the report and submits either a non-compliance report or an approval form to the PM. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or

vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.

- C. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Agent will notify the Architect/Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities.
- D. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

FUNCTIONAL PERFORMANCE TESTING

OBJECTIVES AND SCOPE

- A. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- B. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, failures, interlocks, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.
- C. Demonstrate the operation of the hardware, software, and all related components and systems to the satisfaction of the Commissioning Authority. Schedule the demonstration with the CxA one month in advance. Demonstration shall not be scheduled until submittals, control hardware and software, TAB Final Report, and the Prefunctional checklists are complete and approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of the additional site visits by the Commissioning Authority for re-demonstration, the Contractor shall reimburse Owner for costs of subsequent CxA site visits.
- D. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All documentation, including as-built drawings, O&Ms, and submittals shall be at the job site before functional testing commences.

DEVELOPMENT OF TEST PROCEDURES

- A. The CxA will develop specific functional checklists test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA will provide a copy of the test procedures in advance to the Sub(s) who shall complete the tests.
- B. The Sub(s) shall review and point out to the CxA any specific problems related to the functional checklists because of feasibility, safety, equipment and warranty protection.

COORDINATION AND SCHEDULING

- A. The GC shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems.
- B. Functional testing is conducted after prefunctional and startup testing has been satisfactorily completed and non-compliance form items have been closed out. The air balancing and water balancing must be completed and debugged before CxA completes a TAB checkout of air-related or water-related equipment or systems.
- C. The CxA will schedule functional tests after written notification from the GC and affected Subs. The CxA shall direct, witness and document the functional testing of equipment and systems with support from the Subs.
- D. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

DOCUMENTATION

- A. The CxA shall witness and document the results of all functional performance tests using the specific functional checklist forms developed for that purpose. Prior to testing, these forms are provided to the GC & Subs for review.

NON-CONFORMANCE

- A. The CxA will record the results of the functional test and TAB checkout on a standard Test Form. All deficiencies or non-conformance issues will be noted and reported to the PM on a standard Issues Log.
- B. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the Test Form.
- C. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to

satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the PM.

- D. The CxA documents deficiencies and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the Issues Log report to the Sub(s), GC and/or PM. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
- E. The CxA reschedules the test and the test is repeated.
- F. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1. The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the PM, the GC and to the Sub representative assumed to be responsible.
 - 2. Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.
 - 3. The CxA documents the resolution process.
 - 4. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA & GC reschedules the test and the test is repeated until satisfactory performance is achieved.

COST OF RETESTING

- A. The contractor and Subcontractors will notify the CxA that the systems are ready for testing. As such, for a given system it is assumed that all specified prefunctional tasks are complete by the contractor or Sub.
- B. If the CxA discovers that the systems are incomplete at the time of the first functional test, the entire system will be marked as deficient and the retesting procedure for deficient systems will be followed.
- C. Deficiencies will be noted by the CxA and documented. Deficiencies are associated with completed systems. For deficiencies not related to any prefunctional checklist or start-up fault, the following shall apply:
 - i. The CxA will conduct retesting (back-check) of the equipment / system once at no charge to the GC for their time.
 - ii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting beyond the initial retesting noted above will be chargeable to the GC.

- iii. The time and expenses for the CxA and PM to direct, coordinate or perform any retesting for items which are a repeated deficiency, previously reported via commissioning deficiency log will be chargeable to the GC.
- iv. The Contractor shall respond in writing to the CxA and PM at least as often as non-compliance reports (Cx Issues Log) are issued. The response shall report the status of each apparent outstanding discrepancy identified during commissioning. Responses shall cover explanations of any disagreements and proposals for their resolution.
- v. The CxA retains the original non-conformance form (Cx Issues Log) until the end of the project.
- vi. The GC shall not consider any required retesting by any Contractor a justified reason for a claim of delay or for a time extension.

APPROVAL

- A. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA, if necessary. The CxA recommends acceptance of each test to the PM using a standard form. The PM gives final approval on each test using the same form, providing a signed copy to the CxA and the Contractor.

OPERATION AND MAINTENANCE MANUALS (O&M'S)

- A. The contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned sixty (60) days in advance of functional testing.
- B. Operation and Maintenance manuals shall conform to requirements detailed in Specification 01 78 00.

OWNER TRAINING

- A. The GC shall be responsible for training coordination, agendas, scheduling and ultimately for ensuring that training is complete per Specification 01 79 00.
- B. The CxA shall be responsible for overseeing and approving the adequacy of the training of Owner personnel for commissioned equipment.
- C. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors are specified in Division 01, 22, 23 and 26.
- D. Each Sub and vendor responsible for training shall submit a written training plan (agenda) to the CxA for review and approval prior to training. The plan shall include the following elements:
 - 1. Equipment (included in training)

2. Intended audience
 3. Location of training
 4. Objectives
 5. Subjects covered (description, duration of discussion, special methods, etc.)
 6. Duration of training on each subject
 7. Instructor for each subject
 8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
- E. The CxA will verify the training was satisfactorily completed and recommend approval of the training to the PM.

WARRANTY AND DEFERRED TESTS

- A. Warranty system testing (10 months after project acceptance) will be conducted and require assistance from the appropriate sub-contractors. Each sub will meet with facility staff to discuss the current building operation and the condition of outstanding issues related to the original commissioning. Problems or concerns they have with operating the building as originally intended will be reviewed, tested and action developed.
- B. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM, A/E, and CxA. These tests will be conducted in the same manner as the seasonal tests as soon as possible.

SEASONAL TESTING

- A. During the warranty period, seasonal testing shall be completed as part of this contract. Seasonal testing is intended to test the performance of systems under full load conditions that cannot be simulated during the functional testing period. For example, it is impossible to test the heating system under full load conditions in July, so the heating system would be full load tested during the winter months. The CxA shall coordinate this activity. Tests will be executed, documented, and deficiencies corrected by the appropriate Subs, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the GC.

END OF COMMISSIONING SPECIFICATION SECTION

SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Time switches.
 - 2. Outdoor and indoor photoelectric switches.
 - 3. Indoor occupancy sensors.
 - 4. Outdoor motion sensors.
 - 5. Lighting contactors.
 - 6. Emergency shunt relays.
- B. Related Sections include the following:
 - 1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Area Lighting Research, Inc.; Tyco Electronics.
 - 2. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 3. Intermatic, Inc.
 - 4. Leviton Mfg. Company Inc.
 - 5. Lightolier Controls; a Genlyte Company.
 - 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 7. Paragon Electric Co.; Invensys Climate Controls.
 - 8. Square D; Schneider Electric.
 - 9. TORK.
 - 10. Touch-Plate, Inc.
 - 11. Watt Stopper (The).
- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
 - 1. Contact Configuration: DPST.
 - 2. Contact Rating: 20-A ballast load, 120/240-V ac.
 - 3. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
 - 4. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
 - 5. Programs: 4 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
 - 6. Programs: 2 channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.
 - 7. Programs: 2 channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.

8. Programs: 2 channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
 9. Programs: 2 channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.
 10. Program: 2 and an annual holiday schedule that overrides the weekly operation on holidays.
 11. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
 12. Astronomic Time: selected channels.
 13. Battery Backup: For schedules and time clock.
- C. Electromechanical-Dial Time Switches: Type complying with UL 917.
1. Contact Configuration: DPST.
 2. Contact Rating: 20-A ballast load, 120/240-V ac.
 3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 4. Astronomic time dial.
 5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 6. Skip-a-day mode.
 7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Area Lighting Research, Inc.; Tyco Electronics.
 2. Grasslin Controls Corporation; a GE Industrial Systems Company.
 3. Intermatic, Inc.
 4. Lithonia Lighting; Acuity Lighting Group, Inc.
 5. Novitas, Inc.
 6. Paragon Electric Co.; Invensys Climate Controls.
 7. Square D; Schneider Electric.
 8. TORK.
 9. Touch-Plate, Inc.
 10. Watt Stopper (The).
- B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 2. Time Delay: 15-second minimum, to prevent false operation.

3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
 4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- C. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 2. Time Delay: 30-second minimum, to prevent false operation.
 3. Lightning Arrester: Air-gap type.
 4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR PHOTOELECTRIC SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. Area Lighting Research, Inc.; Tyco Electronics.
 3. Eaton Electrical Inc; Cutler-Hammer Products.
 4. Grasslin Controls Corporation; a GE Industrial Systems Company.
 5. Intermatic, Inc.
 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. MicroLite Lighting Control Systems.
 8. Novitas, Inc.
 9. Paragon Electric Co.; Invensys Climate Controls.
 10. Square D; Schneider Electric.
 11. TORK.
 12. Touch-Plate, Inc.
 13. Watt Stopper (The).
- B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 3. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
 4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

- C. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit mounted on luminaire, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 3. Light-Level Monitoring Range: 1000 to 10,000 fc, with an adjustment for turn-on and turn-off levels within that range.
 4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 4. Novitas, Inc.
 5. RAB Lighting, Inc.
 6. Sensor Switch, Inc.
 7. TORK.
 8. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.

7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.
- D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.
- E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 LIGHTING CONTACTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
 3. Eaton Electrical Inc.; Cutler-Hammer Products.
 4. GE Industrial Systems; Total Lighting Control.

5. Grasslin Controls Corporation; a GE Industrial Systems Company.
6. Hubbell Lighting.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
8. MicroLite Lighting Control Systems.
9. Square D; Schneider Electric.
10. TORC.
11. Touch-Plate, Inc.
12. Watt Stopper (The).

- B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.
 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.6 EMERGENCY SHUNT RELAY

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Lighting Control and Design, Inc.
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
1. Coil Rating: 120 V.

2.7 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

2. Operational Test: Verify operation of each lighting control device and adjust time delays.

- B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 0923

SECTION 26 2200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - 1. Distribution transformers.

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. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Qualification Data: For testing agency.
- E. Source quality-control test reports.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."
- F. Efficiency – Per DOE 10 CFR 431.192.
- G. Testing on 600 volt rated equipment to be done using a 1000-volt meggar. All new wire shall hold at least 100 meg ohms.

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.

1.7 SUPPORT SYSTEMS

- A. The following minimum mounting and installation guidelines shall be followed for transformer support, unless specifically modified by the above referenced standards.
 - a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.
 - b. Provide a letter of conformance for the support frame, signed and sealed by a Professional Engineer registered in the Project State.
 - c. Pre-engineered structures such as "GEARSTACKER" products, (www.gearstacker.com), will be acceptable provided the submittal contains complete documentation for the specific support application.
 - d. The E.C. is to coordinate any additional required wall bracing with G.C. prior to work beginning.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of 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.
- D. CSA 802.2-00 Minimum Efficiency Values for Dry Type Transformers

Energy Conservation Standards for Low-Voltage Dry-Type Distribution Transformers			
Single phase		Three phase	
kVA	Efficiency (%)	kVA	Efficiency (%)
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

Note: All efficiency values are at 35 percent of nameplate-rated load.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Cores: One leg per phase.

- D. Enclosure: Ventilated, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- E. Enclosure: Ventilated, NEMA 250, Type 3R.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- F. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: ANSI 49 gray.
- G. Taps for Transformers 7.5 to 24 kVA: Manufacturer's Standard
- H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with EPA 2005, efficiency levels.
 - 2. Tested according to NEMA TP 2.
- K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
 - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 - 2. Include special terminal for grounding the shield.
 - 3. Shield Effectiveness:
 - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
 - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.
- L. Wall Brackets: Manufacturer's standard brackets.
- M. Sound-Level Requirements: NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution or buck-boost transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 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. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- B. Remove and replace units that do not pass tests or inspections and retest as specified above.
- C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2200

SECTION 26 2413 - SWITCHBOARDS

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. E.C. responsible for all Breaker Testing required.
- C. Gear manufacturer shall provide a full coordination study to the Engineer for approval during submittal process. Coordination Study is to be sealed by an engineer licensed in North Carolina.
- D. A. Switchboard shall be provided with painted "schematic" bus on front of enclosure to depict actual bus arrangement inside cubicles.
- E. Provide a laminated drawing of the building electrical riser next to each switchboard in the main electrical room framed and mounted under glass.
- F. Primary current injection testing of the GFPE equipment is required and a written record of the test should be included in final project documents per NEC 230.95 (C).

1.2 SUMMARY

- A. Section Includes:
 - 1. Service and distribution switchboards rated 600 V and less.
 - 2. Transient voltage suppression devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
 - 7. Identification.
 - 8. Mimic bus.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - 6. Detail utility company's metering provisions with indication of approval by utility company.
 - 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 - 9. Include diagram and details of proposed mimic bus.
 - 10. Include schematic and wiring diagrams for power, signal, and control wiring.
 - 11. The engineer of record must seal and sign the manufacturers' Short-Circuit Analysis.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Qualification Data: For qualified Installer.
- E. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- F. 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.
- G. Operation and Maintenance Data: For switchboards 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. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. 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.
- F. Comply with NEMA PB 2.

- G. Comply with NFPA 70.
- H. Comply with UL 891.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.7 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 - 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards 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.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).
- D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Architect's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion of work.

1.10 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- C. Nominal System Voltage: as indicated on the drawings.
- D. Main-Bus Continuous: silver plated copper of the ampacity as indicated on the drawings.
- E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- F. Indoor Enclosures: Steel, NEMA 250, Type 1.
- G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- H. Barriers: Between adjacent switchboard sections.
- I. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- J. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - 1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
 - 2. Space-Heater Power Source: Transformer, factory installed in switchboard.
- K. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal

blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

- L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- M. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.
- N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- O. Pull Box on Top of Switchboard:
 - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 - 2. Set back from front to clear circuit-breaker removal mechanism.
 - 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 - 4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- P. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: silver plated hard-drawn copper of 98 percent conductivity, copper feeder circuit-breaker line connections.
 - 2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 - 3. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - 4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - 5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - 6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- Q. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

- R. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- S. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated to interrupt the short-circuit current available at terminals. Series ratings are not allowed.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - 6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

- e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
- 1. Fixed circuit-breaker mounting.
 - 2. Two-step, stored-energy closing.
 - 3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time time adjustments.
 - c. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - 5. Remote trip indication and control.
 - 6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 8. Control Voltage: 120-V ac. Retain one of first two paragraphs below.
- C. Breakers 600A or larger shall be a solid state trip type.

2.3 INSTRUMENTATION

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated: All values to be in true RMS.
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Phase current Demand.
 - k. VA Demand.
 - l. VAR demand
 - m. Contact devices to operate remote impulse-totalizing demand meter.
 - n. 4 output relays and 4 isolated analog outputs that can replace transducers
 - o. The Power Meter shall have built-in data communications to allow Multi-point communication to multiple computer workstations, programmable controllers, and other host devices, at a minimum data rate of 9600 baud. The Power Meter shall be able to communicate with the Owners Tridium Niagara Software through the Network Area Controller, NAC, Panel for building management and/or other monitoring functions. The Power Meter shall be compatible with Modbus RTU Communications.
 - p. The Power Meter shall be able to perform Harmonic Analysis with trigger trace memory, waveform capture, event recorder and data logger.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.4 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Not Used.
- C. Not Used.
- D. Not Used.
- E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Not Used.
- C. Not Used.
- D. Not Used.
- E. Not Used.

2.6 IDENTIFICATION

- A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
 1. Nameplate: At least 0.032-inch- thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

- B. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- C. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- D. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- E. Upon completion of installation, and prior to final inspection, the contractor shall reduce in size the "as-built" single line diagram (riser), frame diagram under glass, and mount in a conspicuous place adjacent to the switchboard.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards 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 switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section " Miscellaneous Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
 - D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 - E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
 - F. Install filler plates in unused spaces of panel-mounted sections.
 - G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 1. Set field-adjustable switches and circuit-breaker trip ranges.
 - H. Install spare-fuse cabinet.
 - I. Comply with NECA 1.

3.3 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Switchboards identified for use as service equipment shall be so labeled.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections as required by the equipment manufacturer to ensure all warranties are valid.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Not used.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After **Final Acceptance**, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Final **Acceptance**.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 5. The following tests shall be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:
 - a. Phase tripping tolerance (within 20% of U/L requirements)
 - b. Trip time (per phase) in seconds.
 - c. Instantaneous trip (amps) per phase.
 - d. Insulation resistance (in megohms) at 100 volts (phase to phase, and line to load).
 6. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.
- F. Switchboard will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. All tests shall be completely documented indicating time of day, date, temperature and all pertinent test information. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for final acceptance of the project.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as indicated.

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

3.9 SHORT CIRCUIT STUDY:

- a. A complete short circuit and protection coordination study with coordination plots for each medium and low voltage distribution system shall be provided. The studies shall include the power company's system and relay characteristics, the base quantities selected, impedance source data, calculation methods and tabulations, one line diagrams, impedance diagrams, conclusions and recommendations. A ground fault study shall be provided for the low voltage system, which shall include the associated zero sequence impedance diagrams. Short circuit momentary duties, when applicable, and interrupting duties shall be calculated on the basis of an assumed fault at each medium voltage switchgear line-up, low voltage switchgear line-up, switchboard, distribution panelboard, pertinent branch circuit panelboard, generator and other significant locations throughout the systems. The short circuit tabulations shall include the fault impedances, X to R ratios, asymmetry factors, KVA symmetrical and asymmetrical fault currents. **This study is to be prepared and sealed by a professional engineer licensed in North Carolina.**
- b. The coordination plots required shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one line diagrams and legends, associated power company's relay or system characteristics, medium voltage fuses and relays, significant equipment starting characteristics, complete parameters for transformers, complete operating bands for low voltage switchgear or switchboard circuit breaker trip devices, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time dial settings and pick up settings required. The long time region of the coordination plots shall indicate a complete tap scale for each medium voltage relay, full load current and 150, 400 or 600 percent full load current transformer parameters and designate the pick ups required for the low voltage circuit breakers. The short time region shall indicate the medium voltage relay instantaneous elements, the magnetizing inrush, ANSI withstand thermal and mechanical transformer parameters, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault currents. Each primary protective device required for a delta-grounded wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, and shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line to ground faults. The transformer damage curve shall be included for each transformer. Low voltage power circuit breakers shall provide long time, long time delay, short time, short time delay, ground fault, ground fault delay, and I^2t in/out settings with coordination plots and shall be separated from each other and the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line to line or line to ground fault. Medium voltage relays shall be separated by a 0.4 second time margin when the maximum three phase fault flows, to assure proper selectivity.

The protective device characteristics or operating band shall reflect the actual symmetrical and asymmetrical fault currents sensed by the device.

- c. The contractor shall note that the drawings and specifications indicate the general requirements for the equipment, the medium voltage and low voltage equipment, but additional specific characteristics of equipment furnished shall be determined in accordance with the results of the short circuit and protection coordination study. The equipment design discrepancies and the proposed corrective modifications, if required, shall be submitted with the short circuit and protection coordination study with any variations clearly noted on the subsequent shop drawings. Necessary field settings, adjustments and minor modifications for conformance with the approved short circuit and protection coordination study shall be accomplished by the particular manufacturer or by the Contractor without additional expense to the Owner. However, should equipment specified be outside the parameters required by this study, a change order to modify the equipment shall be issued if the engineer's review warrants such a change. Equipment shop drawings shall not be submitted until the short circuit and protection coordination study has been reviewed by the Owner's engineer.
- d. Arc-Flash labels shall be printed per OSHA requirements and shall be installed by the contractor.

PART 3: EXECUTION

POINT SETTINGS:

- a. The Electrical Contractor shall set and calibrate all target points and settings indicated on the approved coordination study prior to energizing and testing the system.
- b. The study shall require the Electrical Contractor to provide the following information:
 - 1. Length, type, resistance, reactance of all cables both medium and low voltages.
 - 2. Fuse curves as required.
 - 3. Utility information.

END OF SECTION 26 2413

SECTION 26 2416 - 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. E.C. responsible for all On-Site Breaker Testing required.
- C. Gear manufacturer shall provide a full coordination study to the Engineer for approval during submittal process.
- D. E.C.is to label service equipment with maximum available fault current per NEC Art 110.24A

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.
 - 4. Transient voltage suppression panelboards.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, 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. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of panelboards and overcurrent protective devices.
 - d. Series Rated Breakers are not permitted.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - f. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
 - 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
 - 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.
- F. Panelboard Schedules: For installation in panelboards.
- G. 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.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- E. 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.
- F. Comply with NEMA PB 1.
- G. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 1. Ambient Temperature: Not exceeding 104 deg F.
 2. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 1. Ambient temperatures within limits specified.
 2. Altitude not exceeding 6600 feet.

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, and encumbrances to workspace clearance requirements.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

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. Keys: Three spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Eaton Corporation; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Protection Div.
 - c. Square D.

2.2 MANUFACTURED UNITS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.
 - 1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 3R.
 - b. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - d. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 6. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.
 7. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
 8. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.
- C. Phase, neutral, bolt-on circuit breakers and Ground Buses:
1. Material: Copper.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
 3. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 5. Split Bus: Vertical buses divided into individual vertical sections.
- D. Conductor Connectors: Suitable for use with conductor material.
1. Main and Neutral Lugs: Compression type.
 2. Ground Lugs and Bus Configured Terminators: Compression type.
 3. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- E. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- F. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- G. The maximum number of breakers in a panelboard shall not exceed 42 poles.
- 2.3 PANELBOARD SHORT-CIRCUIT RATING
- A. Fully rated to interrupt symmetrical short-circuit current available at terminals.
 - B. Series rated equipment is not allowed.
- 2.4 DISTRIBUTION PANELBOARDS
- A. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - B. Main Overcurrent Protective Devices: Circuit breaker, see plans.

- C. Branch Overcurrent Protective Devices:
 - 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 - 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.6 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: UL 489, with full rating to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A and larger. A push-to trip button shall be provided on the cover for mechanically tripping the breaker. The breaker shall have reverse connection capability and be suitable for mounting and operating in any position.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - 1. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 - 3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

4. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
10. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.
11. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

2.7 CONTROLLERS

- A. Motor Controllers: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
 1. Individual control-power transformers.
 2. Fuses for control-power transformers.
 3. Bimetallic-element overload relay.
 4. Indicating lights.
 5. Seal-in contact.
 6. 2 convertible auxiliary contacts.
 7. Push buttons.
 8. Selector switches.
- B. Contactors: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
 1. Individual control-power transformers.
 2. Fuses for control-power transformers.
 3. Indicating lights.
 4. Seal-in contact.
 5. 2 convertible auxiliary contacts.
 6. Push buttons.
 7. Selector switches.
- C. Controller Disconnect Switches: Fused switch Adjustable instantaneous-trip circuit breaker integrally mounted mounted adjacent to and interlocked with controller.

1. Auxiliary Contacts: Integral with disconnect switches to de-energize external control-power source.
- D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
 1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. Control-Power Source: 120-V branch circuit.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.
- C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Mount top of trim 74 inches above finished floor, unless otherwise indicated.
- D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Install overcurrent protective devices and controllers.
 1. Set field-adjustable switches and circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub five 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated phenolic nameplate mounted with corrosion-resistant screws. Nameplate colors shall be consistent.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Load Balancing: After 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.

- D. Infrared Scanning: Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

G. FEEDER INSULATION RESISTANCE TESTING

1. All 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 done with a 500 volt megger. The procedures listed below shall be followed:
 - a. Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between conductors and between conductor and the grounding conductor.
 - b. 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. He 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.
 - c. At final inspection, the contractor shall furnish a megger and show the engineers and State Construction Office representatives that the phase, neutral, and ground bus within panels comply with the above requirements. He shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives.

H. GROUND SYSTEM TESTING

1. Upon completion of installation of the electrical grounding and bonding systems, the ground resistance shall be tested with a ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, appropriate action should be taken to reduce the resistance to 25 ohms, or less, by driving additional ground rods. (The compliance should be demonstrated by retesting.)

I. CIRCUIT BREAKER TESTS

1. For services 1000 amperes and larger, the following tests should be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:
 - a. Phase tripping tolerance (within 20% of U/L requirements).
 - b. Trip time (per phase) in seconds.
 - c. Instantaneous trip (amps) per phase.
 - d. Insulation resistance (in megaohms) at 100 volts (phase to phase, and line to load).
 - e. Set final trip functions to match the engineers approved overcurrent protection device coordination and arc flash study.
 - f. Ground fault protection on circuit breakers shall be tested in the field in accordance with
the NEC and properly calibrated and set to match the coordination and arc flash studies.
 - g. List all breakers settings on the as-built drawings.

J. GROUND FAULT PROTECTION SYSTEM

1. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.

K. DOCUMENTATION

1. All tests specified shall be completely documented indicating time of day, date, temperature and all pertinent test information.
2. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for, final acceptance of the project.

- L. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.

3.5 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.6 SHORT CIRCUIT STUDY:

- A. A complete short circuit and protection coordination study with coordination plots for each medium and low voltage distribution system shall be provided. The studies shall include the power company's system and relay characteristics, the base quantities selected, impedance source data, calculation methods and tabulations, one line diagrams, impedance diagrams, conclusions and recommendations. A ground fault study shall be provided for the low voltage system, which shall include the associated zero sequence impedance diagrams. Short circuit momentary duties, when applicable, and interrupting duties shall be calculated on the basis of an assumed fault at each medium voltage switchgear line-up, low voltage switchgear line-up, switchboard, distribution panelboard, pertinent branch circuit panelboard, generator and other significant locations throughout the systems. The short circuit tabulations shall include the fault impedances, X to R ratios, asymmetry factors, KVA symmetrical and asymmetrical fault currents.
- B. The coordination plots required shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one line diagrams and legends, associated power company's relay or system characteristics, medium voltage fuses and relays, significant equipment starting characteristics, complete parameters for transformers, complete operating bands for low voltage switchgear or switchboard circuit breaker trip devices, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time dial settings and pick up settings required. The long time region of the coordination plots shall indicate a complete tap scale for each medium voltage relay, full load current and 150, 400 or 600 percent full load current transformer parameters and designate the pickups required for the low voltage circuit breakers. The short time region shall indicate the medium voltage relay instantaneous elements, the magnetizing inrush, ANSI withstand thermal and mechanical transformer parameters, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault currents. Each primary protective device required for a delta-grounded wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, and shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line to ground faults. The transformer damage curve shall be included for each transformer. Low voltage power circuit breakers shall provide long time, long time delay, short time, short time delay, ground fault, ground fault delay, and I^2t in/out settings with coordination plots and shall be separated from each other and the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line to line or line to ground fault. Medium voltage relays shall be separated by a 0.4 second time margin when the maximum three phase fault flows, to assure proper selectivity. The protective device characteristics or operating band shall reflect the actual symmetrical and asymmetrical fault currents sensed by the device.
- C. The contractor shall note that the drawings and specifications indicate the general requirements for the equipment, the medium voltage and low voltage equipment, but additional specific

characteristics of equipment furnished shall be determined in accordance with the results of the short circuit and protection coordination study. The equipment design discrepancies and the proposed corrective modifications, if required, shall be submitted with the short circuit and protection coordination study with any variations clearly noted on the subsequent shop drawings. Necessary field settings, adjustments and minor modifications for conformance with the approved short circuit and protection coordination study shall be accomplished by the particular manufacturer or by the Contractor without additional expense to the Owner. However, should equipment specified be outside the parameters required by this study, a change order to modify the equipment shall be issued if the engineer's review warrants such a change. Equipment shop drawings shall not be submitted until the short circuit and protection coordination study has been reviewed by the Owner's engineer.

- D. Arc-Flash labels shall be printed per OSHA requirements and shall be installed by the contractor.

3.7 POINT SETTINGS:

- A. The Electrical Contractor shall set and calibrate all target points and settings indicated on the approved coordination study prior to energizing and testing the system.
- B. The study shall require the Electrical Contractor to provide the following information:
 - 1. Length, type, resistance, reactance of all cables both medium and low voltages.
 - 2. Fuse curves as required.
 - 3. Utility information.

END OF SECTION 26 2416

SECTION 26 2726 - 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 the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge suppression units.
4. Wall-box motion sensors.
5. Isolated-ground receptacles.
6. Snap switches and wall-box dimmers.
7. Solid-state fan speed controls.
8. Wall-switch and exterior occupancy sensors.
9. Communications outlets.
10. Pendant cord-connector devices.
11. Cord and plug sets.
12. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

- B. Related Sections include the following:

1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.

- F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

- 1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

2. Leviton Mfg. Company Inc. (Leviton).
3. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Receptacles shall be industrial specification grade or heavy duty grade meeting NEMA WD 1, NEMA WD 6, DSCC W-C-596G, UL-498 and shall be approved third-party listed.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL5351 (single), CR5352 (duplex).
 - b. Leviton; 5891 (single), 5352 (duplex).
 - c. Pass & Seymour; 5381 (single), 5352 (duplex).
 2. Receptacles shall have side wired terminals with brass screws and hex head grounding screw.
- B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CR 5253IG.
 - b. Leviton; 5362-IG.
 - c. Pass & Seymour; IG6300.
 2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
- C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL8300SG.
 - b. Leviton; 8300-SGG.
 - c. Pass & Seymour; 63H.

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; GF20.
 - b. Pass & Seymour; 2084.
 - c. Leviton

2.4 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL2310.
 - b. Leviton; 2310.
 - c. Pass & Seymour; L520-R.
- B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; 2310-IG.
 - b. Pass & Seymour
 - c. Hubbell
 - 2. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
 - 1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 - 2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 - 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - b. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - c. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
 - 2. Wall switches shall have a side wired terminal with brass screws and hex head grounding screw.
 - 3. Toggle switches shall have quiet operating mechanisms without the use of mercury switches. All switches shall be listed by an approved third-party agency, approved for the voltage and amperage indicated.
- C. Pilot Light Switches, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HPL1221PL for 120 V and 277 V.
 - b. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - c. Pass & Seymour; PS20AC1-PLR for 120 V.
 - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1221L.
 - b. Leviton; 1221-2L.
 - c. Pass & Seymour; PS20AC1-L.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1557.
 - b. Leviton; 1257.
 - c. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1557L.
 - b. Leviton; 1257L.
 - c. Pass & Seymour; 1251L.

2.8 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square law dimming curve. On-off switch positions shall bypass dimmer module.
1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
1. Continuously adjustable slider,

2. Three-speed adjustable slider, 1.5 A.

2.10 OCCUPANCY SENSORS

A. Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; WS1277.
 - b. Leviton; ODS 10-ID.
 - c. Pass & Seymour; WS3000.
2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

B. Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; AT120 for 120 V, AT277 for 277 V.
 - b. Leviton; ODS 15-ID.
 - c. Watt Stopper
2. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

C. Long-Range Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATP1600WRP.
 - b. Leviton; ODWWV-IRW.
 - c. Pass & Seymour; WA1001.
2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft..

D. Long-Range Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATD1600WRP.
 - b. Leviton; ODW12-MRW.
 - c. Watt Stopper (The); DT-200.
2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft..

E. Wide-Range Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATP120HBRP.
 - b. Leviton; ODWHB-IRW.
 - c. Pass & Seymour; HS1001.
2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft..

F. Exterior Occupancy Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; PS200-10.
 - b. Watt Stopper (The); EW-100-120.
 - c. Hubbell
2. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.11 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following: Cooper, Pass & Seymour, Hubbell, Leviton.
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; 40649.
 - b. Hubbell
 - c. Pass & Seymour
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following: Cooper, Pass & Seymour, Hubbell, Leviton.
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; 40595.
 - b. Hubbell
 - c. Pass & Seymour

3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.12 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: See the Plans.
 3. Material for Unfinished Spaces: See the plans.
 4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in "wet locations."
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with lockable cover.

2.13 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: See the Plans.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: See the Plans.

2.14 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Hubbell Incorporated; Wiring Device-Kellems.
 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 3. Leviton
- B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 1. Service Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks.
 2. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.

3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category 5e voice and data communication cables.

2.15 MULTIOUTLET ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the Cooper, Pass & Seymour, Hubbell, Leviton.
- B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Wire: No. 12 AWG.

2.16 SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
 1. Poles: Nominal 2.5-inch- square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
 2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
 3. Finishes: Satin-anodized aluminum.
 4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
 5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
 6. Voice and Data Communication Outlets: Blank insert with bushed cable opening.

2.17 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 1. Wiring Devices Connected to Normal Power System: See the Plans., unless otherwise indicated or required by NFPA 70 or device listing.
 2. Wiring Devices Connected to Emergency Power System: Red.
 3. TVSS Devices: Blue.

4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Receptacles shall not utilize "push-in modular" connectors.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors online and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- B. Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 2726

SECTION 26 2813 - 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. This Section includes the following:
 - 1. Cartridge fuses rated 600 V and less for use in switches panelboards switchboards controllers and motor-control centers.
 - 2. Spare-fuse cabinets.

1.3 SUBMITTALS

- A. Product Data: Include the following for each fuse type indicated:
 - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 - 2. Let-through current curves for fuses with current-limiting characteristics.
 - 3. Time-current curves, coordination charts and tables, and related data.
 - 4. Fuse size for elevator feeders and elevator disconnect switches.
- B. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - 1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - 2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
- C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - a. Let-through current curves for fuses with current-limiting characteristics.
 - b. Time-current curves, coordination charts and tables, and related data.
 - c. Ambient temperature adjustment information.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses 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 NEMA FU 1.
- D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.7 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. Fuses: Quantity equal to 5 percent of each fuse type and size, but no fewer than 3 of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussman, Inc.
 - 2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3 SPARE-FUSE CABINET

- A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Service Entrance: Class L, time delay J, fast acting J, time delay T, fast acting.
- B. Feeders: Class L, time delay J, time delay RK5, time delay.
- C. Motor Branch Circuits: Class RK5, time delay.
- D. Other Branch Circuits: Class RK1, time delay.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 26 2813

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Bolted-pressure contact switches.
 - 4. High-pressure, butt-type contact switches.
 - 5. Molded-case circuit breakers.
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. 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, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.

3. Short-circuit current rating.
 4. UL listing for series rating of installed devices.
 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
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.
- F. Manufacturer's field service report.
- G. 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.
 2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- 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.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

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. Spares: For the following:
 - a. Potential Transformer Fuses: 3
 - b. Control-Power Fuses: 3
 - c. Fuses and Fusible Devices for Fused Circuit Breakers: 3

- d. Fuses for Fusible Switches: 3
 - e. Fuses for Fused Power Circuit Devices: 3
2. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
- 1. Eaton Corporation; Cutler-Hammer Products.
 - 2. General Electric Co.; Electrical Distribution & Control Division.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Group Schneider.
- B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Nonfusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Accessories:
- 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
 - 3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.3 FUSED POWER CIRCUIT DEVICES

- A. Bolted-Pressure Contact Switch: UL 977; operating mechanism shall use a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts.
 - 1. Manufacturers:
 - a. Boltswitch, Inc.
 - b. Eaton Corporation; Cutler-Hammer Products.
 - c. Pringle Electrical Mfg. Co.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D/Group Schneider.

2.4 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
 - 1. Eaton Corporation; Cutler-Hammer Products.
 - 2. Moeller Electric Corporation.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Group Schneider.
- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
 - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
 - 6. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
6. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
8. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

E. Molded-Case Switch Accessories:

1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay. Provide "dummy" trip unit where required for proper operation.
5. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.5 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

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.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

3.3 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.5 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.
- B. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
 - 4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- C. Perform the following field tests and inspections and prepare test reports:
 - 1. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Infrared Scanning:
 - a. Initial Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
 - b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Completion.
 - c. Instruments, Equipment and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

- A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

- B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 26 2816

SECTION 263213 - ENGINE GENERATORS - DIESEL

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 packaged engine-generator sets for emergency power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Performance requirements for sensitive loads.
 - 5. Load banks.
 - 6. Sound Attenuated Level 1 Outdoor enclosure.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.
- 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. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.
 6. Report of exhaust emissions showing compliance with applicable regulations. Including compliance with US EPA emission restrictions for stationary emergency generators.
 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For packaged engine generators 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. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. 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.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 99.
- J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- K. Comply with UL 2200.
- L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- N. **GENERATOR AND COMPONENTS ARE TO BE PROVIDED AS A UL LISTED PIECE OF EQUIPMENT/SYSTEM.**
- 1.6 PROJECT CONDITIONS
- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Architect's written permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
1. Ambient Temperature: -5 to 40 deg C.
 2. Relative Humidity: 0 to 95 percent.
 3. Altitude: Sea level to 1000 feet (300 m).
- C. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 07 Section "Roof Accessories."
- C. Emergency battery light fixture within the genset enclosure to illuminate the control should the engine/generator fail to operate.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period. This shall include all parts, labor, travel to and from job site and expenses and equipment necessary to perform replacement and/or repairs.
1. Warranty Period: 5 years from date of final inspection and acceptance.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 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. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 1. Caterpillar; Engine Div.
 2. Kohler Co.; Generator Division.
 3. Onan/Cummins Power Generation; Industrial Business Group.
 4. MTU

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 2. Output Connections: Three-phase, four wire.
 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements. Maximum 10 seconds starting.

E. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

- D. Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine shall be water cooled, solid-injection type, either vertical in-line or v-type. The engine shall be equipped with fuel filter, lube oil filter, intake air filter, lube oil cooler, service meter, gear-driven water pump, and instruments, including a fuel pressure gauge, water temperature gauge, lubricating oil pump and pressure gauge, battery charging ammeter, and engine hour meter.
- F. Engine shall be provided with oil and water drains to exterior of enclosure with a bronze body ball valve installed on engine and plumbed to exterior coupling with high quality hose. Fumes disposal shall be extended to radiator discharge using an oil resistant high quality hose.
- G. Engine Fuel System:
1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- H. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Engine shall be equipped with one jacket water heater with recirculating pump. Heaters and pump shall be a single assembly with a single point power feed connection.
- I. Governor: Adjustable isochronous, with speed sensing.
- J. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

- K. Muffler/Silencer: Critical Grade type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
 2. Critical grade silencer shall be provided to reduce engine exhaust noise to a maximum dBA level of 85 at a distance of 10 feet.
 3. Terminate exhaust piping using a hinged cap on top of pipe to keep out rain. Exhaust piping and silencer shall be stainless steel to prevent rusting or be internally mounted. Exhaust pipe size shall be such that exhaust back pressure does not exceed maximum limitation required by engine manufacturer. Silencer shall provide a minimum of 32 dBA attenuation.
 4. Acoustic insulation shall reduce engine generator noise to an average of 79 dBA at 23 feet. Air intake and discharge inlets shall be supplied. Acoustic insulation material shall consist of sound absorbing material.
 5. Engine silencer shall be independently supported from the engine-generator.
- L. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- M. Air flow shall be away from engine. The radiator shall be protected by a strong grille or screen guard and the fan shall be provided with a screen guard.
- N. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging. Batteries shall be industrial grade lead acid with current limiting battery charger. Batteries shall be oversized for proper starting in temperature extremes. The battery charging system shall be automatic, solid state, current limiting and float equalizing and shall maintain the battery at normal capacity, recharge battery after cranking and be capable of recharging a completely discharged battery within 8 hours. System shall be capable of automatically switching from one charging rate to another to meet the needs of the battery. The battery charging system shall have a 120 volt input and shall also be equipped with overload protection, voltage surge suppressors, D.C. ammeter, D.C. voltmeter, low D.C. voltage alarm relay, battery charger malfunction alarm contact and have a minimum continuous output of 10 amperes D.C. and be third party listed.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 6A minimum shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
9. Engine shall have radio frequency suppression.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 2085 fuel oil tank. Features include the following:
 1. Tank level indicator.
 2. Capacity: Fuel for a minimum of 8 hours continuous operation at 100 percent rated power output
 3. Vandal-resistant fill cap.
 4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set. Generator parameters shall be able to be monitored through the Building Automation System (BAS) via LonWorks, Modbus, or approved equal.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
- E. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 - 1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - 2. Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards."
 - 3. Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-Voltage Switchgear."
 - 4. Current and Potential Transformers: Instrument accuracy class.
- F. Indicating and Protective Devices and Controls:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.
 - 6. Engine lubricating-oil pressure gage.
 - 7. Running-time meter.
 - 8. Ammeter-voltmeter, phase-selector switch(es).
 - 9. Generator-voltage adjusting rheostat.
 - 10. Start-stop switch.
 - 11. Overspeed shutdown device.
 - 12. Coolant high-temperature shutdown device.
 - 13. Coolant low-level shutdown device.
 - 14. Oil low-pressure shutdown device.
 - 15. Fuel tank derangement alarm.
 - 16. Fuel tank high-level shutdown of fuel supply alarm.
 - 17. Generator overload.
 - 18. Overcrank.
 - 19. ATS in normal.
 - 20. ATS in emergency.
 - 21. Low gas pressure.
 - 22. Enclosure breach.
- G. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- H. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring and Control."

- I. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
 - 1. Engine high-temperature shutdown.
 - 2. Lube-oil, low-pressure shutdown.
 - 3. Overspeed shutdown.
 - 4. Remote emergency-stop shutdown.
 - 5. Engine high-temperature prealarm.
 - 6. Lube-oil, low-pressure prealarm.
 - 7. Fuel tank, low-fuel level.
 - 8. Low coolant level.
- J. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Panels, alarms, meters, etc., shall be appropriately labeled using laminated plastic labels, red letters on white background, professionally engraved. Contractor shall submit a drawing for approval showing layout prior to purchase or fabrication.
- K. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
- L. The generator set shall have a digital control panel mounted on the unit with LCD readout and controls listed by the manufacturer as standard as well as those specified herein. Controls shall provide for automatic shutdown in case of high water temperature, overspeed, overcrank, or low oil pressure. Include additional alarms for NFPA 110 and 99 compliance.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
 - 1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices. Furnish with auxiliary position contacts.
 - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
 - 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 - 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

- 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 - 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Drip-proof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof, galvanized steel housing (minimum 14 gauge), wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure. Housing shall be painted aluminum, 14 gallon minimum, with access doors with panic hardware. Doors shall provide full access for operation and servicing and be lockable via in-handle lock tumblers.
- B. Coordinate first paragraph and subparagraphs below with Drawings showing features, construction details, and equipment arrangement.

- C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
 - 1. AC lighting system and connection point for operation when remote source is available.
 - 2. DC lighting system for operation when remote source and generator are both unavailable.
 - 3. Provide battery backup emergency light within genset to illuminate control panel if normal power is de-energized and the generator fails to start.
 - 4. Provide a self-contained emergency light within enclosure to illuminate the control panel if normal power is lost and the generator fails to start. Minimum 90 minute backup, ni-cad battery.
- E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.9 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: Bridge-bearing neoprene, complying with AASHTO M 251.
 - 2. Durometer Rating: 45.
 - 3. Number of Layers: Two.
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Color shall be UNCC standard green finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 - 2. Full load run.
 - 3. Maximum power.
 - 4. Voltage regulation.
 - 5. Transient and steady-state governing.
 - 6. Single-step load pickup.
 - 7. Safety shutdown.
 - 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 - 9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Contractor shall provide a separate concrete pad for generator enclosure. Pads shall be a minimum of 12" beyond base x 12" deep with No.6 rebar on 12" centers in a horizontal grid pattern. Rebar should clear surfaces by 3" minimum in all directions. Concrete mixture shall be a 1:2:3 mixture of cement, sand, and aggregate with maximum of 4" slump and 28-day compressive strength of 3000psi.

- D. Install remote radiator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of [1 inch (25 mm)] on concrete base on grade.
- E. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- F. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
 - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping."
- F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: All testing shall be demonstrated to the owner's commissioning agent.

- B. All testing shall be demonstrated to the owner's commissioning agent.
- C. Perform a 4 hour load bank test which shall be witnessed by owner's commissioning agent. On-site testing in the presence of the owner shall include testing of all safety devices and shall include a four hour running test first at 50% load for 1 hour, then at 75% load for 1 hour and last at 100% load for 2 hours. Then, after the cool down period the generator shall be started and after 10 seconds be applied 100% load for 30 minutes. The capability of the system to pick up full standby service load within 10 seconds of power outage shall also be demonstrated. Supplier shall furnish load bank.
- D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- E. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- F. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 - 7. Exhaust Emissions Test: Comply with applicable government test criteria. The Engine Generator must be able to meet Mecklenburg County emissions requirements (Tier 4).
 - 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 - 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- G. Coordinate tests with tests for transfer switches and run them concurrently.
- H. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- I. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- J. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- K. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- L. Remove and replace malfunctioning units and retest as specified above.
- M. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- N. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- O. Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."
- B. Supplier shall provide complete on-site training in the operation of the systems for the Owner at times chosen by the Owner to include all work shifts.
- C. Supplier shall provide, upon completion of installation but before final acceptance by Owner, three complete sets of operating instructions, maintenance manuals, and drawings, showing full details for care and maintenance of each item of equipment. In addition, a simplified set of stepby-step operating instructions, encased in a suitable frame for placing at the generator location, shall be provided with the operation and maintenance manuals.

END OF SECTION 263213

SECTION 26 3600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 General Notes

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Switch shall be 4-wire, 4-pole, 100% rated continuous.
- C. Ensure compliance with 2017 NFPA 70, 700.10(D)(3), 'Generator Control Wiring', as amended by NFPA Tentative Interim Amendment, TIA 17-17.

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.
 - 2. Remote annunciation systems.
 - 3. Remote annunciation and control systems.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For each type of product 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. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.

- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.
- J. Transfer switch shall be completely assembled, wired, and tested at the factory prior to shipping and installation.

1.5 PROJECT CONDITIONS

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

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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contactor Transfer Switches:
 - a. Zenith
 - b. ASCO
 - c. Russelectric.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location. The minimum withstand rating shall be 42,000 amps.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver plated copper. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Switching shall incorporate a time adjustable transition neutral position where the load is disconnected from both power sources.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

- L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- M. Enclosures: General-purpose NEMA 250, Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
- N. All transfer switch coils, springs, and control elements shall be easily inspected and conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.
- O. All feeder lugs, relays, timers, control wiring, and accessories shall be front accessible.
- P. The control module and transfer switch shall be physically separate.
- Q. Controls shall be digital incorporating LCD backlit display visible while the enclosure door is closed.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent flashover, and shall be arranged so that the transfer switch can be manually operated under load, without opening the enclosure door.
- D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

- F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- G. Automatic Delayed -Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
 - 1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
 - 2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
 - 3. Fully automatic break-before-make operation with center off position.
 - 4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.
- H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Motor Disconnect and Timing Relay: Controls designate starters, so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- J. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
- K. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Timed auxiliary contacts. Two individually timed N.O.-N.C. contacts.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.
 - d. A selectable load/no-load digitally programmable exerciser shall be incorporated within ATS.
14. The switch shall automatically transfer to the emergency source in less than 10 seconds upon loss of utility power.

15. Loss of utility power on any phase, or reduction of voltage on any phase below 80%, the transfer switch shall cause generator start.

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- D. Testing Agency's Tests and Inspections:
 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.

- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

END OF SECTION 26 3600

SECTION 26 4113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. 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 lightning protection for building elements. Specification is provided for performance specification and shall be used to provide a contract price for lightning protection system. Contractor shall provide a UL master label lightning protection system for the building including all required conductors, equipment, raceways and design.

1.3 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

- A. Product Data: For air terminals and mounting accessories.
- B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
- C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
- D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.
- E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.
- B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Automatic Lightning Protection.
 - 2. ERICO International Corporation.
 - 3. Harger Lightning Protection, Inc.
 - 4. Heary Bros. Lightning Protection Co. Inc.
 - 5. Independent Protection Co.
 - 6. Robbins Lightning Inc.
 - 7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Roof-Mounting Air Terminals: NFPA Class I, aluminum, solid, unless otherwise indicated.
 - 1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.
- C. Stack-Mounting Air Terminals: Stainless steel.

- D. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A and NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.
- C. Conceal the following conductors:
 - 1. System conductors.
 - 2. Down conductors.
 - 3. Interior conductors.
 - 4. Conductors within normal view from exterior locations at grade within 200 feet of building.
 - 5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.
- E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.
- G. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.
 - 1. Bond ground terminals to counterpoise conductor.
 - 2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
 - 3. Bond grounded metal bodies on building within 12 feet of roof to counterpoise conductor.
- H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.
- B. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION 26 4113

SECTION 26 4313 - TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 TVSSs for low-voltage power, control, and communication equipment.
- B. Related Sections include the following:
 - 1. Division 26 Section "Wiring Devices" for devices with integral TVSSs.
 - 2. Division 26 Section "Switchboards" for factory installed TVSSs.
 - 3. Division 26 Section "Panelboards" for factory installed TVSSs.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed voltage rating.
- C. TVSS: Transient voltage surge suppressor.
- D. SPD: Surge Protection Device

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the following standards:
 - 1. UL 1283.
 - 2. UL 1449.
- C. Qualification Data: For testing agency.

- D. Field quality-control test reports, including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- E. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.
- F. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- F. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- G. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F.
 - 3. Humidity: 0 to 85 percent, noncondensing.
 - 4. Altitude: Less than 20,000 feet above sea level.

1.7 COORDINATION

- A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.
- B. Coordinate surge protection devices with Division 26 Section "Electrical Power Monitoring and Control."

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of final acceptance of work.
- B. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.9 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. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Protection Technologies, Inc.
 2. Current Technology, Inc.
 3. Surge Suppression Incorporated.
 4. Cutler-Hammer, Inc.; Eaton Corporation.
 5. Entrelec International.
 6. Intermatic, Inc.
 7. LEA International.
 8. Leviton Mfg. Company Inc.
 9. Liebert Corporation; a division of Emerson.
 10. Northern Technologies, Inc.
 11. Siemens Energy & Automation, Inc.
 12. Square D; Schneider Electric.
 13. Sutton Designs Inc.
 14. Transtector Systems, Inc.
 15. Tycor; Cutler-Hammer, Inc.
 16. United Power Corporation.

2.2 SERVICE ENTRANCE SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

8. LED indicator lights for power and protection status.
 9. Audible alarm, with silencing switch, to indicate when protection has failed.
 10. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 11. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 240 kA per phase.
- D. Connection Means: Permanently wired.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120.
 2. Line to Ground: 400 V for 208Y/120.
 3. Neutral to Ground: 400 V for 208Y/120.
- F. Protection modes and UL 1449 SVR for voltages of 480, 3-phase, 4-wire, circuits shall be as follows:
1. Line to Line: 1000 V for 480 V.
 2. Line to Ground: 1000 V for 480 V.

2.3 PANELBOARD SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 7. LED indicator lights for power and protection status.
 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 9. One set of dry contacts rated at 5 A and 250-V, ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.

10. Surge-event operations counter.

C. Peak Single-Impulse Surge Current Rating: 80 kA per phase.

D. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 400 V for 208Y/120.
2. Line to Ground: 400 V for 208Y/120.
3. Neutral to Ground: 400 V for 208Y/120.

E. Protection modes and UL 1449 SVR for voltages of 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 1000 V for 480 V.
2. Line to Ground: 800 V for 480 V.

2.4 SUPPRESSORS FOR ELECTRONIC-GRADE PANELBOARDS

A. Surge Protection Device Description: Sine-wave-tracking type, panel-mounted design with the following features and accessories:

1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
4. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

B. Peak Single-Impulse Surge Current Rating: 120 kA per phase.

C. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 400 V for 208Y/120.
2. Line to Ground: 400 V for 208Y/120.
3. Neutral to Ground: 400 V for 208Y/120.

D. Protection modes and UL 1449 SVR for voltages of 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 1000 V for 480 V.
2. Line to Ground: 800 V for 480 V.

2.5 PLUG-IN SURGE SUPPRESSORS

- A. Description: Non-modular, plug-in suppressors with at least four 15-A, 120-V ac, NEMA WD 6, Configuration 15-15R receptacles, suitable to plug into a NEMA WD 6, Configuration 15-15R receptacle; with the following features and accessories:
 - 1. LED indicator lights for power and protection status.
 - 2. LED indicator lights for reverse polarity and open outlet ground.
 - 3. Circuit breaker and thermal fusing. When protection is lost, circuit opens and cannot be reset.
 - 4. Circuit breaker and thermal fusing. Unit continues to supply power if protection is lost.
 - 5. Close-coupled direct plug-in.
 - 6. Rocker-type on-off switch illuminated when in the on position.
 - 7. One RJ11/12C telephone line protector, suitable for modem connection. Maximum clamping voltage 220 peak on pins No. 3 and No. 4.
- B. Peak Single-Impulse Surge Current Rating: 26 kA per phase.
- C. Protection modes and UL 1449 SVR shall be as follows:
 - 1. Line to Neutral: 475 V.
 - 2. Line to Ground: 475 V.
 - 3. Neutral to Ground: 475 V.

2.6 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTION DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide multipole, 60-A circuit breaker as a dedicated disconnect for suppressor, unless otherwise indicated.

3.2 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect panelboards to their sources until surge protection devices are installed and connected.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust equipment installation, including connections, and to assist in field testing. Report results in writing.
 - 1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. Testing: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports:
- C. Testing: Perform the following field tests and inspections and prepare test reports:
 - 1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Complete startup checks according to manufacturer's written instructions.
- D. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transient voltage suppression devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 4313

SECTION 26 5100-INTERIOR 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. This Section includes the following:
 - 1. Interior lighting fixtures, lamps, and ballasts.
 - 2. Emergency lighting units.
 - 3. Exit signs.
 - 4. Lighting fixture supports.
 - 5. Retrofit kits for fluorescent lighting fixtures.
 - 6.

1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CRI: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. RCR: Room cavity ratio.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.

2. Emergency lighting units including battery and charger.
 3. Ballast.
 4. Energy-efficiency data.
 5. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 23 Section "Diffusers, Registers, and Grilles."
 6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, and Grilles."
 7. Life, output, and energy-efficiency data for lamps.
 8. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
 - b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
1. Wiring Diagrams: Power and control wiring.
- C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Lighting fixtures.
 2. Suspended ceiling components.
 3. Structural members to which suspension systems for lighting fixtures will be attached.
 4. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Sprinklers.
 - d. Smoke and fire detectors.
 - e. Occupancy sensors.
 - f. Access panels.
 5. Perimeter moldings.
- D. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:
1. Lamps: Specified units installed.
 2. Accessories: Cords and plugs.
- E. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

- F. Qualification Data: For agencies providing photometric data for lighting fixtures.
- G. Field quality-control test reports.
- H. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.
- F. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
 - 1. Obtain Architect's approval of fixtures for mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Completion.
- G. Lighting systems must comply with the 2012 N.C. Energy Code and N.C. Senate Bill 668.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of final acceptance of work. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 - 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Entire unit shall be warranted for three years from final acceptance of work. The battery must have two more years of prorated warranty.
- B. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Electronic Ballasts: Five years from date of final acceptance from final acceptance of work.
 - 2. Warranty Period for Electromagnetic Ballasts: Three years from date of final acceptance of work.
- C. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
 - 1. Warranty Period: 3 year(s) from date of final acceptance of work.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Battery and Charger Data: One for each emergency lighting unit.
 - 4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- B. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
- C.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- I. Plastic Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

- a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
 - b. UV stabilized.
- 2. Glass: Annealed crystal glass, unless otherwise indicated.
- J. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.
- K. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 23 Section "Diffusers, Registers, and Grilles."
 - 1. Air Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
 - 2. Heat Removal Units: Air path leads through lamp cavity.
 - 3. Combination Heat Removal and Air Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air supply units.
 - 4. Dampers: Operable from outside fixture for control of return-air volume.
 - 5. Static Fixture: Air supply slots are blanked off, and fixture appearance matches active units.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. Provide luminaire disconnecting means as per 2011 NEC 410.73 (G)
- B. Ballast to be U/L Listed, Class P. Ballast shall meet or exceed ANSI C82.11.
- C. Electronic Ballasts: Comply with ANSI C82.11; rapid-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.
 - 1. Sound Rating: A.
 - 2. Total Harmonic Distortion Rating: Less than 10 percent.
 - 3. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 4. Operating Frequency: 20 kHz or higher.
 - 5. Lamp Current Crest Factor: 1.7 or less.
 - 6. BF: 0.71 or higher.
 - 7. Power Factor: 0.95 or higher.
 - 8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- D. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following:
 - 1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 - 2. Automatic lamp starting after lamp replacement.
 - 3. Sound Rating: A.
 - 4. Total Harmonic Distortion Rating: Less than 20 percent.

5. Transient Voltage Protection: IEEE C62.41, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. BF: 0.95 or higher, unless otherwise indicated.
 9. Power Factor: 0.95 or higher.
- E. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection. All fluorescent fixtures shall have electronic ballasts.
1. Ballast Manufacturer Certification: Indicated by label.
- F. Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- G. Ballasts for Low-Temperature Environments:
1. Temperatures 0 Deg F and Higher: Electronic or electromagnetic type rated for 0 deg F starting and operating temperature with indicated lamp types.
 2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.
- H. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- I. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to 5 percent of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to 20 percent of normal.
 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
- J. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.
1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 30 percent of rated lamp lumens.
 2. Ballast shall provide equal current to each lamp in each operating mode.
 3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.
- 2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS
- A. Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: A.
 4. Total Harmonic Distortion Rating: Less than 20 percent.
 5. Transient Voltage Protection: IEEE C62.41, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. BF: 0.95 or higher, unless otherwise indicated.
 9. Power Factor: 0.95 or higher.
 10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
 11. Ballast Case Temperature: 75 deg C, maximum.
- B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to 5 percent of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to 20 percent of normal.
 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5 EMERGENCY FLUORESCENT POWER UNIT

- A. References to battery backup of lighting fixtures apply to emergency fixtures supplemental to the emergency generator circuits. See electrical Plans.
- B. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Night-Light Connection: Operate one fluorescent lamp continuously.
 3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 4. Battery: Sealed, maintenance-free, nickel-cadmium type.
 5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
- C. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Night-Light Connection: Operate one fluorescent lamp in a remote fixture continuously.
 3. Battery: Sealed, maintenance-free, nickel-cadmium type.
 4. Charger: Fully automatic, solid-state, constant-current type.
 5. Housing: NEMA 250, Type 1 enclosure.
 6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.6 BALLASTS FOR HID LAMPS

- A. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features, unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F for single-lamp ballasts.
 3. Normal Ambient Operating Temperature: 104 deg F.
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
1. Lamp end-of-life detection and shutdown circuit.
 2. Sound Rating: A.
 3. Total Harmonic Distortion Rating: Less than 15 percent.
 4. Transient Voltage Protection: IEEE C62.41, Category A or better.
 5. Lamp Current Crest Factor: 1.5 or less.
 6. Power Factor: .90 or higher.
 7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

8. Protection: Class P thermal cutout.
 9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.
 10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 50 percent of rated lamp lumens.
 - c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
 11. Continuous Dimming Ballast: Dimming range shall be from 100 to 35 percent of rated lamp lumens without flicker.
 - a. Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
 - b. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
- C. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output.
- D. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter-starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - a. Restrike Range: 105- to 130-V ac.
 - b. Maximum Voltage: 250-V peak or 150-V ac RMS.
 2. Minimum Starting Temperature: Minus 40 deg F.
 3. Open-circuit operation shall not reduce average lamp life.
- 2.7 EXIT SIGNS
- A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.

- b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
3. Master/Remote Sign Configurations:
- a. Master Unit: Comply with requirements above for self-powered exit signs and provide additional capacity in LED power supply for power connection to remote unit.
 - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.8 EMERGENCY LIGHTING UNITS

- A. Description: Self-contained units complying with UL 924.
- 1. Battery: Sealed, maintenance-free, lead-acid type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 - 7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
 - 8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in

tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.9 FLUORESCENT LAMPS

- A. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.
- B. T8 rapid-start low-mercury lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours, unless otherwise indicated.
- C. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.
- D. T5 rapid-start low-mercury lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000 K, and average rated life of 20,000 hours, unless otherwise indicated.
- E. T5HO rapid-start, high-output low-mercury lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.
- F. Compact Fluorescent Lamps: 4-Pin, low mercury, CRI 80 (minimum), color temperature 3500K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.
 1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
 2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
 3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
 4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
 5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
 6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

2.10 HID LAMPS

- A. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.
 1. Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.

- B. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000 K.
- C. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.
- D. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.

2.11 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports, and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.
 - 2. The lay in luminaire shall then be screwed to the main runners of the lay in ceiling track at all four (4) corners using sheet metal screws.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3. Supports shall be provided with same type of wire as used to support the lay-in ceiling track.
 5. Wall mounted Emergency lighting shall be mounted above an average person's reach (7ft.min.)
- C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- E. Adjust aimable lighting fixtures to provide required light intensities.
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal. Contractor shall perform a test on each unit after it is permanently installed and charged for a minimum of 24 hours. Battery shall be tested for 90 minutes. The test shall demonstrate that the batteries conform to the requirement of NEC 700.12 (F). The battery test shall be done 10 days prior to final inspection by the State Construction Office. Any unit which fails the test must be repaired or replaced and tested again. Copy of the test report shall be sent to the State Construction Office.
- B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 5100

SECTION 26 5119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior solid-state luminaires that use LED technology.
 - 2. Lighting fixture supports.

1.2 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, arranged by designation.
- B. Shop Drawings: For nonstandard or custom luminaires.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.

2. Laboratory Test Reports for Credit IEQ 4.2: For paints and coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- D. Product Schedule: For luminaires and lamps.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved:
- B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
- C. Product Certificates: For each type of luminaire.
- D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Final Inspection and acceptance.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. CRI of 80. CCT of 4000 K.
- F. Rated lamp life of 50,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- H. Internal driver.
- I. For indoor and building mounted fixtures, provide minimum 2-KV surge suppression integral with the driver (5-KV preferred if available).
- J. Nominal Operating Voltage: As circuited on the drawings.
 1. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

2.3 MATERIALS

- A. Metal Parts:
 1. Free of burrs and sharp corners and edges.
 2. Sheet metal components shall be steel unless otherwise indicated.
 3. Form and support to prevent warping and sagging
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

1. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

2.4 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm)
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports: Sized and rated for luminaire weight.
- E. Flush-Mounted Luminaire Support: Secured to outlet box.
- F. Wall-Mounted Luminaire Support:
 1. Attached to structural members in walls.

2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
2. Ceiling mount with pendant mount with 5/32-inch diameter aircraft cable supports adjustable to 120 inches.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Secure with a screw at each corner to a MAIN ceiling runner.

J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 26 5119

SECTION 26 56 19

LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 General Notes

- A. All exterior Light Poles, 12ft and taller, shall be UL listed or approved 3rd party listed.

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

- A. Section Includes:
 - 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
 - 3. Luminaire-mounted photoelectric relays.

1.4 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.5 ACTION SUBMITTALS

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

1. Arrange in order of luminaire designation.
 2. Include data on features, accessories, and finishes.
 3. Include physical description and dimensions of luminaire.
 4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 5. Photometric data and adjustment factors based on laboratory tests, complying with [IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79.
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
 6. Wiring diagrams for power, control, and signal wiring.
 7. Photoelectric relays.
 8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
- B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.
- C. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports and seismic restraints.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Luminaires.
 2. Structural members to which equipment and luminaires will be attached.
 3. Underground utilities and structures.
 4. Existing underground utilities and structures.
 5. Above-grade utilities and structures.
 6. Existing above-grade utilities and structures.
 7. Building features.
 8. Vertical and horizontal information.
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.
- C. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of the following:
1. Luminaire.
 2. Photoelectric relay.
- E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- F. Source quality-control reports.
- G. Sample warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.
1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
 2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- F. Comply with IEEE C2, "National Electrical Safety Code."
- G. Comply with NFPA 70, "National Electrical Code."
- H. Comply with NECA/IESNA 501, "Standard for Installing Exterior Lighting Systems."

- I. Comply with UL 1598, "Standard for Luminaires."
- J. Comply with UL 8750, "Standard for Safety for Light Emitting Diode (LED) Equipment for Use in Lighting Products."
- K. Comply with IESNA LM-79, "Electrical and Photometric Measurements of Solid-State Lighting Products".
- L. Fixtures will be required to be DesignLights Consortium compliant (DLC). Fixtures specified must meet DLC certification or supplier will be responsible for submitting an "equal" fixture to the listed schedule fixture.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

2.3 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. UL Compliance: Comply with UL 1598 and listed for wet location.
- D. CRI of minimum 80. CCT of 4000 K.
- E. L70 lamp life minimum of 50,000 hours.
- F. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- G. Internal driver. Provide a quick disconnect for driver and diode board.
- H. Mercury-free.
- I. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.

- B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
 - 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
 - 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 - 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.5 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - a. Color: Dark bronze.
- D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

- C. Examine walls, roofs, canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming. [Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.]
- J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

- A. Aim as indicated on Drawings.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s), as applicable to the specific luminaire use:
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

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

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

Infrastructure Standards for Installation

University of North Carolina Wilmington

INFRASTRUCTURE STANDARDS FOR INSTALLATION

Standards as of 04/01/2020

Provided by ITS

IOS / NETWORK & COMMUNICATIONS

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Overview

The University of North Carolina Wilmington is constructing new buildings and renovating existing buildings both on and off main. This document defines voice and data cabling requirements for all future installations. The university recognizes that the integrity of the cabling systems and the use of proper installation techniques by qualified contractors, are essential for implementing a dependable network. Bandwidth requirements and fault tolerance is an important aspect of the structured solution and taken into consideration with the infrastructure design.

Purpose

The university will implement an end-to-end manufacturer's solution that has resulted in the approval of three manufacturers:

1. CommScope SYSTIMAX® Solutions GigaSPEED XL Category 6 Structured Cabling System and Corning Cable Systems LANscape solution
2. CommScope SYSTIMAX® Solutions GigaSPEED X10D Category 6A Structured Cabling System with x91B reduced diameter cable and Corning Cable Systems LANscape solution (Access Solutions)
3. CommScope NETCONNECT/Uniprise® CAT 6 CS37 cabling system and the Corning Cable Systems LANscape
4. CommScope NETCONNECT/Uniprise® CAT 6A CS47 cabling system and the Corning Cable Systems LANscape (Access Solutions)
5. Belden System 2400 (for horizontal cabling). 2412 shall be installed. Key Connect work station outlets and Key Connect patch panels.
6. Belden System 10GXS (for wireless access point cabling). Belden System 3612 and/or 10GXS cabling shall use Belden's REVConnect modular termination system, in appropriate category, supporting either jacks or plugs. Belden System 3600 and/or 10GXS cable shall be installed. Optical fiber system shall be Corning Cable Systems LANscape solution.

This specification is to ensure that UNCW meets with a standards compliant end-to-end cabling solution with guaranteed “Channel” performance. This solution will allow UNCW to maximize productivity and value by minimizing down time and operational expenses, thus warranting our investment for 20 Years, while still providing for a future path to evolving technologies. Each of these solutions requires the contractor to provide Manufacturer certification:

1. CommScope SYSTIMAX Category 6 and Category 6A solutions require the contractor to be a current PartnerPRO network member; installers, supervisors, designers to have a current valid certification.
2. CommScope NETCONNECT/Uniprise Category 6 and Category 6A solutions require contractor to be a current PartnerPRO network member; installers, supervisors, designers to have a current valid certification.
3. Belden solution requires the contractor to be a Belden Partner Alliance (PA) program member.
4. Corning solution requires the installers to be a current EWP.

Solution Description

The SCS Solution shall utilize a network of fiber optic and unshielded twisted pair, riser, ty and station cables. Cables and terminations located as shown and in the quantities indicated on the drawings. Fiber cables shall terminate on wall- or rack-mounted fiber patch panels located in all demarcation and termination points shown on the drawings. All cables shall terminate in an alphanumeric sequence at all termination locations. All standard copper cable terminations shall comply with, and be tested to latest revision of TIA-568-C family of standards for Category 6 and/or beyond Category 6 installations. Horizontal cabling for wireless access points (WAPs) shall comply with, and be tested to latest revision of TIA-568-C family of standards for Category 6A and/or beyond Category 6 installations. Available and unused pairs between the Equipment Room (ER) and Telecommunications Room(s) (TR) shall terminate and identified as spare at each location. Station cables shall terminate on three or four gang wall plates equipped as shown on the drawings. All copper terminations will be T-568B wiring.

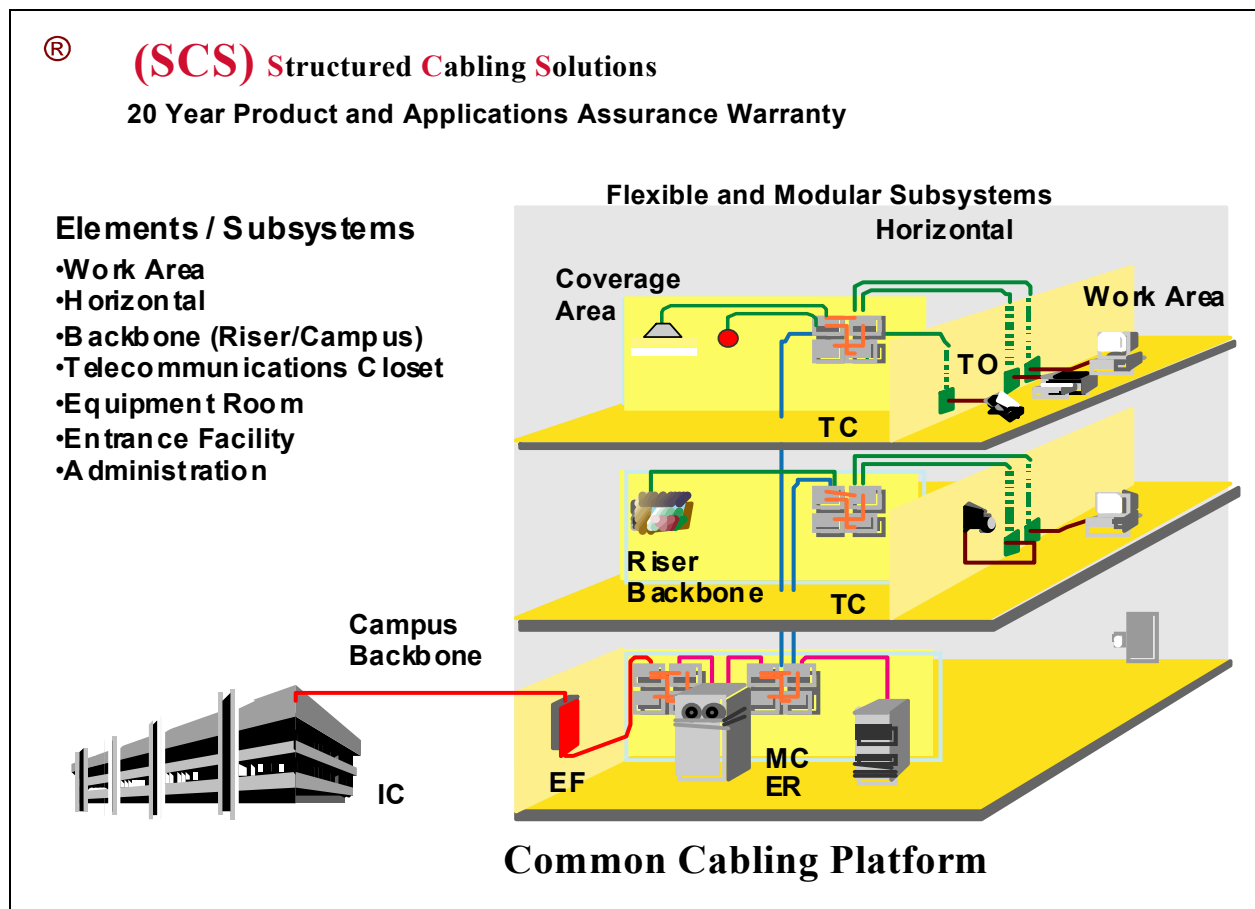
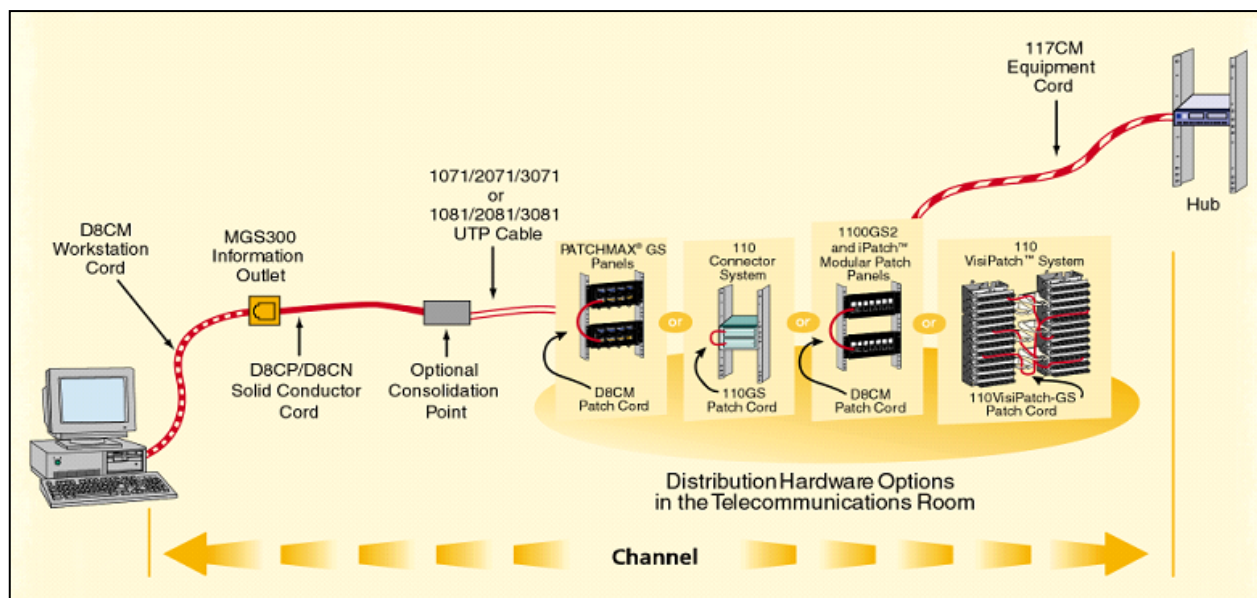


Diagram 1 - Structured Cabling Solution

Channel Performance Specifications

The SCS solution for standard cable drops shall support a useable end-to-end system bandwidth of not less than 400 MHz. This requires substantial performance margin in all key electrical parameters beyond Category 6. Useable end-to-end system bandwidth is indicated by the maximum frequency at which a positive Power Sum Attenuation-to-Crosstalk Ratio may be obtained at both the Near (PSACRN) and Far ends (PSACRF) of a 100-meter cabling channel. This channel shall have the capability of four or six connections without failing to meet Category 6 specifications.

The required cabling system described is a “Beyond Category 6” structured cabling solution.



The SCS solution for wireless access points (WAPs) shall support a useable end-to-end system bandwidth of not less than 500 MHz. This requires substantial performance margin in all key electrical parameters beyond Category 6A. Useable end-to-end system bandwidth is indicated by the maximum frequency at which a positive Power Sum Attenuation-to-Crosstalk Ratio may be obtained at both the Near (PSACRN) and Far ends (PSACRF) of a 100-meter cabling channel. This channel shall have the capability of four or six connections without failing to meet Category 6A specifications.

The required cabling system described is a “Beyond Category 6A” structured cabling solution.

Installation Specifics

The installation contractor shall be responsible for installing, terminating, testing, and labeling the cabling system in accordance with TIA and BICSI installation guidelines for intra and inter building. The contractor will also provide UNCW with a dedicated project manager for the life of the project who is responsible for planning the installation schedule and act as the interface with UNCW employees. Weekly update meetings will be required. The contractor will also provide UNCW with the certified installation warranty certificate at the completion of the project. This will insure that UNCW will be able to maintain a warranty on their installed communication systems.

A single manufacturer shall provide all unshielded twisted pair (UTP) end-to-end Channel (as defined by latest revision of TIA-568-C family of wiring standards) configurations. The horizontal cabling to station outlets shall consist of UTP, riser rated (CMR) cable at a minimum.

Each standard data cable shall be 'Beyond' Category 6 rated to a minimum of 400 megahertz and shall be third party verified to comply with or exceed TIA Category 6 requirements.

Each cable for wireless access points (WAPs) shall be a "Beyond" Category 6A cable rated to a minimum of 500 MHz. Each cable for WAPs shall be third party verified to comply with or exceed Category 6A requirements, and shall carry be capable of supporting 100W Power-Over-Ethernet over 100 meters.

References for the project and standards shall be as required to include:

- A. TIA-568-C.2 (or latest revision)
- B. TIA-569-D (or latest revision)
- C. TIA-606-C (or latest revision)
- D. TIA-607-C (or latest revision)
- E. NETA ATS (or latest revision)
- F. NFPA 70 (or latest revision)
- G. UL 969 (or latest revision)
- H. ISO/IEC 11801 (or latest revision)
- I. BICSI TDMM (or latest revision)
- J. BICSI CO-OSP (or latest revision)
- K. STS-1000 (or latest revision)
- L. Standards of Installation of Infrastructure Network Communications at UNCW

Number of Drops per Room

Faculty/Staff Offices, Class Rooms, Conference Rooms

Will have a minimum of four (4), beyond Category 6 rated and one (1) - coax terminated on a video coupler insert or campus wide access outlet as determined on the print. Additional drops installed as requested. Each horizontal UTP cable shall terminate on one RJ-45 jack at the workstation. The termination method on the rear of the jack shall be Insulation Displacement Contact (IDC) type connectors. The pin assignments shall conform to TIA-568- B standard T568B. Rooms less than 100 square feet will have one (1) standard information outlet and rooms 100 square feet or more will have two (2) information outlets. An information outlet is two (2) voice and two (2) data.

Each information outlet will have a minimum of two (2) voice and two (2) data outlets.

Wall phone locations

Wall telephone outlets shall use Suttle 063187 or approved functional equivalent. The wall phone jack will be stainless steel and have mounting lugs with screw down termination. The mounting position will provide enough room for a standard wall phone w/ADA jack beside it.

Data Projectors

Each data projector will have a minimum of three cat 6 or beyond data cables installed.

A/V Equipment Racks

Each rack will have a minimum of five cat 6 or beyond data cables.

TR Inter-connects

Will have a minimum of three (3), Cat 6 for each Closet. Also an additional cross-connect for every twenty-four (24) installed Cat 6 jacks beyond the first twenty-four (24) connections.

Print Machines

Will have a minimum of one (1) dedicated Cat 6 for each device.

Vending Machines

minimum of one (1) dedicated Cat 6 for each device.

Will have a

Irrigation Clocks

minimum on one (1) dedicated Cat 6 with in line protection installed (Ditek or equivalent). The installation will determine the cable used to meet code.

Will have a

Water Meter(s)

Each water meter will have a minimum of one (1) dedicated cat 6 to each location. Installation of one voice line will be required in addition to the data line.

JACE (HVAC) Communications

Each JACE location will have a Standard drop on One (1) voice and two (2) data. The standard drop is within two feet of the JACE location.

Freezer Location

standard drop for each location.

Will have one (1)

Television Location and Monitor Locations

(2) data outlets.

Will have two

Intercom Cabling

Each Intercom unit will have one (1) dedicated data cable from the data rack in the Communications room.

Each Intercom

Wireless Access Point Outlets and installation:

Wireless access points shall terminate on a dedicated 6A patch panel that matches the structured cabling solution being installed. Each wireless access point will have two (2) dedicated cat 6A cables installed. The certified voice and data contractor for the project will install the exterior and interior wireless access points provided by the University.

Conference and Auditorium

16 to 25 seat- 2 outlets

25 to 30 seat- 3 outlets

30 to 50 seat-4 outlets

50 to 75 seat-5 outlets

75 to 100 seat- 6 outlets

Work rooms – 2 outlets

Hallways – every 100 feet

Main Electrical rooms- one per room

Primary Mechanical rooms- one per room

Cable Installation

Cabling Termination practices: The installer will observe the cabling practices described in the TIA-568-C family of standards. Standard industry practices guided by the latest revisions of BICSI TDMM and BICSI installation manuals are required for cable installation, handling, grooming, etc. Installation of cabling is in a manner that will protect the cable from damage during install, facilitate cable management and identification and provide a neat and groomed appearance. The horizontal cables shall be bundled in the ER/TR ladder tray using Velcro cable ties. Plastic ty-wraps are unacceptable. During the installation, nicks, abrasions, burning, and scuffing of cable are unacceptable and will be prevented. Replacement of damaged cables are at the contractor's expense regardless of whether the cable passes Category 6 Level III testing standards.

Cross-connect fields 110 or
GigaBIX IDC connecting clips or blocks for every installed cable pair at the rack and WAO.

Horizontal station cable

Should have twelve inches of spare cable at the station outlet and 10 feet of spare at each rack
Category 5e power sum cables and fiber riser cable between the ER/TR

Outside plant Category 3: Eight feet spare at each protector block.

Fiber terminating into the building: as per industry best practices, last 15 feet of fiber cable to be cut off and discarded after pulling, still leaving 20 feet of spare at each rack.

Network Data Connections

Manufacturer certification is required for installers. Information outlet terminations will be to manufacturer's specifications. The installer is responsible for end-to-end termination of all the cabling.

All data cable is blue in color unless changed by environmental standards.

Network and Communications – Telephony

All voice cable shall be Category 6 or beyond Category 6 rated. Telecommunication's voice cable is white jacketed. Manufacturer certification is required for installers. Information outlet terminations will be to manufacturer's specifications. The installer is responsible for end-to-end termination of all the cabling.

Telephone Trunk Cables

Cables of 25 pair and up are 24 AWG, LSPR Power Sum (Category 5e) solid conductor cables. These high pair-count cables terminate on 110-style 360 pair for the SYSTIMAX system, the Belden termination solution or the NECTONNECT Category 5e solution. The punch-down order is the traditional USOC color code order for Multi-pair telephone cables Punched on 110 blocks with insulation displacement connectors installed. All terminations will be on a dedicated voice rack.

Jacks (inserts, all installations)

Category 6 jack data jacks are yellow in color

Category 6 jack telecommunications voice jacks are white in color

When specifying Belden copper systems, jacks and modular plugs shall be from Belden's Key Connect & REVConnect product family. REVConnect is only for WAP locations.

CATV video coupler kits are white in color.

Work Area Outlet (WAO) faceplate is white with a minimum of four ports with label insert top and bottom.

Campus Copper Voice Backbone

The connection for each building on campus is with a PE-89 rated outdoor copper cable consisting of a minimum of 25 pairs. Termination shall be consistent with the units used for the voice backbone. Terminations will be on protector blocks with 110 in/110 out. Each pair on the protector block use 4c1s 5 pin solid-state protector modules. The underground or inter-building cable installation, termination, and testing by the voice /data contractor.

Campus Fiber-Optic Data Backbone

From the MDF to the IDF(s)

The data cables used between the MDF to the IDF(s) will be a fiber-optic cable consisting of a minimum twelve single-mode fibers. The number and type of fiber and quantities required are according to the existing and future network requirements. The existing cables are Siecor or Corning Cable Systems fiber optic cable and terminated with LC connectors mounted in Corning

Cable Systems LANscape rack-mounted hardware in the top position of the data rack. All twelve strand fibers must terminate in twelve port interconnect panels.

Between Buildings

Existing buildings use Corning Cable systems duct/aerial hybrid loose-tube fiber-optic cable. Existing hardware is the Corning Cable systems landscape rack-mounted hardware. The University, according to the existing and future network requirements will specify the number and type of fibers.

UNCW is a splice free fiber optic campus. Fiber optic cable splicing is unacceptable for any fiber optic cabling: outside plant or Intra-building.

Outside plant, fiber will terminate in Data rack fiber patch panels in each MDF.

Backbone fiber will terminate in each MDF and TR in a data rack fiber patch panel, either Corning Cable Systems LANscape.

This backbone cable shall consist of a minimum of 24 single-mode fibers.

The cable termination is with LC connectors and rack-mounted hardware.

The minimum count is 24 single mode fibers.

Communications Room/Equipment Room

The ER/TR(s) for each building provide for a transition between the horizontal and backbone pathways, and provide space for Network communications components including cable terminations (horizontal and backbone), active and passive equipment, cross-connections cabling, and hardware, and any other materials or equipment associated with the building Network communications, data and technology systems. All Communications Rooms shall have direct access to the hallway or other such corridor. Network communications rooms are dedicated space. Building services such as Electrical (i.e. Electrical Distribution Panels or Transformers) poses a threat of damage or EMI interference that makes them completely unacceptable for Network Communications Equipment and wiring. Supporting codes are in the TIA-568B-C and TIA-569 wiring standard unequivocally against Multi-Use Communications

rooms. In existing buildings, due to age of the building and design criteria at that, time space shared with other trades exists until the building's renovation or space is available.

1. Network communications doors should not open into network communications Rooms.
2. Network communications Rooms shall not contain any type of sink or storage for Custodial or any other such supplies.
3. Network rooms MDFs, IDF: - do not allow storage of any kind (i.e. Books, Furniture, A/C Filters, Light Bulbs, AV Equip. etc....).
4. Floors in Network Communications Rooms shall be sealed concrete or tile. Carpeted floors are totally unacceptable for Network Communications rooms due to the associated static electricity they create posing a threat of damage to sensitive Network Electronics.
5. A minimum space of 10 ft. X 10 ft. X 8 ft. H is required for all Network Communications Rooms or as required by TIA-569-A designs considerations. Square foot size: 10,000: 10 ft. X 11 ft.; 8,000 sq. ft.: 9 ft. X 10 ft. and 5,000 sq. ft.: 7 ft. X 10 ft.
6. All walls of the Network communications room are covered in ¾" non- fire rated plywood horizontally, be void free and finished on one side; mounted 4 inches above finish floor (AFF) the total perimeter of the room. The Non-fire rated plywood has at least two coats of fire resistant white paint. The paint applied is on all six sides with a minimum of two coats. The final paint finish shall be clear of footprints, markings, etc. and be a smooth finished product. NO exceptions. The plywood will be mounted eight (8) foot vertically and four (4) foot wide around the entire communications room.
7. All Network Communications locations shall be equipped with a grounding bus bar. A solid copper grounding bus bar ¼-inch thick x4 inches high with compression fittings and standoff brackets with insulators will be required on the Network communications backboard.
8. Bus bar connection is to a backbone of insulated, solid copper (minimum #6 AWG, with 3/0 recommended). This backbone is to the main grounding bus bar in the electrical entrance facility that bonds back to the building's grounding system. This point should be at an electric panel per NEC 2005 standards. Chatsworth grounding bar 10622-010 or equivalent. The grounding bar location is mounted above the horizontal cable tray in the TR.
9. Each telecom Room connection to the MCC has a minimum of eight LSPR Power Sum Cables (Category 5e). Cables that installed outdoors will be PE-89 type and

- terminated on 110 in/ 110 out building protectors at each end. Each building entrance protector will be fully loaded with C4B1S (PTC) solid-state protector modules. The pair counts used for this backbone will vary by project due to connection requirements.
10. Each rack will also house a minimum of one (1) rack-mounted surge suppressor or UPS as specified on the print.
 11. TIA-569-D Standards usage for lighting, HVAC, perimeters and dust design are required.
 12. Fire Alarm panel installation in the TR or the ER not permitted.
 13. Electrical outlets mounted at eighty-two (82) inches above AFF to top of outlet.
 14. All electrical outlets are on the emergency generator. If the building does not have an emergency generator circuit prepping for future installed is required.
 15. Installation of electrical conduits, refrigerant pipes, water pipes, HVAC ducting or piping, elevator alarms or pump alarms cannot penetrate through the communication or ER rooms.
 16. Dedicated duplex 20 amp 110 VAC outlets on separate circuits are required. Convenience outlet mounting is at six foot. Intervals around the perimeter.
 17. One- L6-20P outlet is required. Outlet is mounted at eight-two (82) inches AFF.
 18. To improve visibility all walls are white in color.
 19. HVAC: 24 hours/day, 365 days a year, 64 degrees to 75 degrees Fahrenheit, 30 to 55% humidity, positive pressure.
 20. Lighting: Typically, 8.5 ft. high providing 50 ft. candles @ three feet above the floor.
 21. Dust: less than 100 micrograms/cubic meter/24-hour period.
 22. Audio Visual (AV) Cabling: AV cabling shall not use the communications rooms: MDF, IDF, and Entrance Facility as a pathway due to legal and auditing problems. The AV cable for riser pathways needs its own dedicated pathway. AV equipment storage is not allowed.
 23. Intercom units: The single data line for each intercom unit is a standard data cable and terminate in the communications room data rack. Network Communications maintain the cable. AV maintains the power supply and must be located in a dedicated area separate from the communications rooms.
 24. Sleeves and Pathways for Communications, data, and fiber optic cabling is dedicated and not to be used by other trades. Each trade is responsible for providing a dedicated pathway that meets code. Ty-wrapping or attaching to communications pathways or supports is not allowed.

25. Racks are two post open frame with three (3) inch deep channel, seven (7) feet in height, nineteen (19) inches wide and have a total of forty-five (45) RU's. Vertical cable management will be a minimum of six (6) inches wide and six (6) inches deep, double sided with covers. Each rack will have a vertical cable manager per side. If two (2) racks are side by side the total Vertical cable manager's width will be twelve (12) inches wide.

Patch Cords

The qualified contractor will provide all patch cords for the project. The voice and data contractor will install the patch cords at the rack end and the WAO locations. The following criteria apply:

1. Patch cords are included in the project and provided by the voice/data contractor for the rack end and the work area outlet(s).
2. Patch cords must be manufactured by the selected end-to-end system manufacturer and must be of correct grade to maintain the beyond Category 6 or beyond Category 6A channel rating.
3. Installation of the patch cords will be by the contractor after review with Network communications.
4. Patch cords for the work area outlet will be 50% 15 feet, 50% 20 feet. Unless otherwise designated by the Network communications department. The quantity for the Work area outlets will be for all Network communications data outlets throughout the facility.
5. Patch cords for each data cable in the data rack(s) of all communications rooms. At the rack end, the patch cords will be 40% 2 feet, 40% 3 feet, and 20% 4 feet.
6. Category 6A patch cords provided by contractor for each wireless access point. The length is a minimum of 5 feet and the quantity is for each wireless access point. The patch cord for the rack end will be included in the data cable quantity.
7. Patch cords will be from one supplier and match the end-to-end solution installed for the project.
8. Patch cords submittals are included for review and include lengths and quantities.

Cable Pathways

Pathways constructed from J-hooks maybe hung from Ceiling Wire installed with powder-actuated devices. J-Hooks will not be attached to independent grid wire or to the existing drop ceiling grid wiring. The added weight to the ceiling grid system can cause distortion in the grid

system. Cable tray usage is for horizontal pathways with options including channel tray, ladder tray, solid bottom, and ventilated. Cable tray with conduit from the wall, stubbed within 6 inches of the cable tray and bonded is the preferred method. Conduits will have a 200 lbs. minimum pull string installed regardless of the length of the conduit. The horizontal cable between the ER/TR and the station outlets may have different support methods.

Proper Use of J-Hooks

Ceiling support shall not exceed manufacturer specification for Category 6 compliance. The maximum span distance will not exceed 5 feet intervals with a maximum of 12 inches of sag between supports. There shall be a minimum distance of 3 inches between the cable support distance and ceiling grid. Cable pathways design is to avoid EMI and RFI Interference. Common causes of this interference are fluorescent lighting fixtures, air handling motors, and many kinds of electrical controls including starters, lighting contractors, and power distribution panels. All cable runs must be at least two feet away from all fluorescent lights and EMF sources. Never run parallel with electrical conduits or strap to them. Every cable, whether an individual or grouped together, shall be supported. Wherever possible, group cables together in pathways. Never cinch plastic cable ties overly tight. If it deforms the outer cable jacket, it is too tight. The ties should be trimmed of any excess length and be snug. Cable splicing is not permitted and violation corrections will be at the contractor's expense.

Unsuitable Conduit

During cable pulling, flexible conduit tends to:

- Creep
- Shift
- Cause sheath damage to the cable

Flexible conduit usage is only in situations where it is the only practical alternative.

NOTE: If flexible conduit is used, its size increases by one trade size relative to the size of a rigid conduit.

IMPORTANT: Flexible conduit (e.g., metal flex conduit) usage in buildings not recommended.

Acceptable conduit runs

Achieve the best direct route (e.g., usually parallel to building lines) with no bend greater than 90 degrees or an aggregate of bends in excess of 180 degrees between pull points or pull boxes. Contain no continuous sections longer than 30.5 m (100 ft.). Conduit bonding is to ground on one or both ends in accordance with national or local requirements. Conduit type selection is to withstand the environment and meet code for installation. NOTE: For runs that total more than 30.5 m (100 ft.) in length, pull points or pull boxes installed so that no segment between

points/boxes exceeds the 30.5 m (100 ft.) limit. Total conduit runs kept to 45.8 m (150 ft.) or less (including the sections through pull boxes).

Identification and Labeling

The contractor with the following criteria will provide labels. Each end of all Category 6 cable labeled at approximately 3 to 6 inches from the Network Data/voice jack, CATV, and with a printed cable label. The contractor with consultation will provide labeling for the faceplate and block terminations from the Information Technology Network Group. All labeling will comply with the TIA-606A standard. The ER/TR labeling nomenclature will match that of the station outlet (SO) identifier as shown in the following information.

1. Rack- mounted 110-block labeling: Each 110-block position (each 4-pair connector clip) will be labeled as follows: Standard SOs/ wall phones outlets FVXX- where FVXX is the SO identifier where the Category 6 or beyond Category 6 cable on that connector clip terminates.
2. Modular patch panel labeling: Each panel has labeling. Each modular jack panel position shall be XXX where XXX matches the SO identifier. The patch panel shall have a label placed on the upper left hand corner of the panel face identifying the panel. All labels for the labeling printed using a computer, printer or Brother p-touch labeler with the TZ tape or equivalent. LABELS SHALL NOT BE HAND WRITTEN. Labels shall be different colors as detailed for identification per the 606B standard. The contractors shall meet with UNCW Telecom personnel, verify the numbering schemes, and label coloring.
3. The general numbering sequence shall conform to a sequential numbering pattern common to all floors of the facility. All cable numbering is sequentially from room to room as closely as possible. The final numbering scheme agreement is between the selected vendor and the building owner, UNCW prior to the start of the physical installation.
4. Station outlet labeling consists of two components: top faceplate label and a bottom faceplate label. The label will consist of a five-character identifier with the format f-y-xxx. F= the floor number of the building, y is D for data or V for voice and xxx is a unique identifier between 0 and 999 for any station outlet on that floor served by the same ER/TR. Faceplate labels for wall phones will consist of 4-character identifier with the format f-v-xxx. F= the floor number, V = is for voice, xx is a unique identifier between 0 and 99.
5. TIA-606 Administration standards for the Network Communications Infrastructure of Commercial Buildings is an incorporated reference. Compliance and shall be maintained.
6. Each cable record must indicate the cable type by manufacturer and manufacturer's designation and document every pair/conductor in the cable. Cable identifier linkage is to all pathways in which it runs.

7. Each piece of termination hardware such as a patch panel or wiring block must be unique named and labeled.
8. Termination position on cross-connect must be identified by type, the pair conductor terminated and a user code.
9. Each element in the route, identification labels should be completed and attached. Labels should meet the requirements of UL969 Standard for Marking and Labeling Systems.
10. A final report should record system configuration, unique identifier, fiber labels, pathways, as-built details, and as-built drawings.
11. Loss Measurements and OTDR traces shall also be included. With the records.
12. Color coding to match 606 requirements.
13. Cable numbering shall follow the example:

D=DATA, V=VOICE
5=NETWORK COMMUNICATIONS ROOM NUMBER
2=FLOOR NUMBER
013=13TH CABLE TO BE INSTALLED
CABLE D.5.2.013
14. Wireless access point labeling: label the grid work at the outlet location with a printed label. Provide WAP in front of the horizontal cable label at the rack end. A green dot on the grid work is for easy location identification.

Example: WAP D.5.2.013

Fiber Labeling

1. The interconnect panel will be labeled on the front glass of the enclosure and include:
 - a. Size and type of the fiber.
 - b. The far end or "TO" will be shown
 - c. The building the fibers termination point location is.
 - d. The Enclosure will be identified.
 - e. The interconnect panel will be identified.
2. Panel A 12 SM to (bldg. abbreviation) Enclosure (A thru Z identified on enclosure) to Panel A thru Z identified on enclosure)
3. EX. Panel A 12 SM to TSC Enclosure D Panel G.

Testing, Documentation and Warranty

Copper category 5e and/or 6 channels shall be tested as appropriate, with only PASSing values accepted, using a TIA-568-compliant Cat 6 Time-Domain Reflectometer. Copper category 6A channels shall be tested, with only PASSing values accepted, using a TIA-568-compliant Augmented Cat 6 (Cat 6A) Time-Domain Reflectometer.

Horizontal Cable Testing

1. Channel testing: Each equipment Network communications room patch cord, patch panel, horizontal cable, RJ 45 jack, Station patch cord will be tested end- to- end for compliance with category 6 level III parameters as stated in the TIA- 568 family of standards. Only certified cat 6-cable testing allowed on each all beyond cat 6 cables. The Test equipment used for horizontal category six cable tests complies with the industry standard Category 6 cable testers level III and comply with TIA test procedures. Each link shall be tested to TIA-568-C pinout, with only PASS results accepted. The contractor, at no charge to UNCW, shall bring any pairs not meeting the requirements of the standard into compliance and complete end-to-end test results documentation to UNCW. The test results will require 2-cd copies.

Fiber Optic Testing

Each 62.5 OR 50/125-micron fiber will be tested patch panel to patch panel at the 850 and 1300 nm wavelength in both directions using a light meter. Each single mode fiber will be tested patch panel to patch panel at the 1310 and 1550 nm wavelength both directions using a light meter. The maximum total attenuation for any single fiber between patch panels will not exceed 2.0 db.

- Power meter tests: For building risers, power meter tests are required.
- Provide a power test and OTDR test for length, attenuation, and micro bends for each individual fiber. Documentation will include the power test and OTDR results.
- Test results included for inclusion into the documentation package.
- Link attenuation does not include any active devices or passive devices other than cable connectors and splices.
- A final report shall be compiled that records system configuration, fiber labels, cable routes, and as-bilts details and as-built drawings.

Computer Generated Report

All cables/connectors shall be tested provide test equipment generated print out for each cable/connector, indicating that the channel end-to-end solution has passed or failed. Test results: Provide two cd copies.

All testing must meet manufacturer's warranty requirements.

Manufacturer Warranty

Contractor shall provide a minimum Twenty (20) year cabling Extended Product Warranty and Application Assurance. The warranty will support any performance claims the manufacturer makes over and above the Cat. Six standards stated herein. A Warranty statement from the Manufacturer stating the period of the warranty for all the products specified for the project and the name and address of the authorized manufacturers agent who will honor the warranty claims.

Extended Product Warranty

The Extended Product Warranty will cover product defects for all passive manufactured channel components. Passive components are those exhibiting no gain or contributing no energy. Manufacturer warrants, from the date a Registration Certificate passes to the end-user, the following:

1. That the passive products that comprise the registered Channel solution will be free from manufacturing defects in material or workmanship under normal and proper use;
2. That all channel approved passive cabling products that comprise the registered channel solution exceed the specification of TIA 568 and exceed ISO/IEC 11801 standards and will be equal to or exceed to the performance specifications of the associated Communication product data sheet in effect at the time the Registration Certificate is issued;
3. That the installation will exceed the insertion and return loss, attenuation and near end cross talk (NEXT) requirements of TIA 568-B and the ISO/IEC 11801 standards for cabling links/channel configurations specified in these standards.
4. That each channel is comprised exclusively of a single manufacturer solution and is capable of delivering 1.2 Gbps (Cat 5e), 3.6 Gbps (Cat 6) or 10 Gbps (Cat 6A) to the workstations or WAPs in accordance with applications standards.
5. This extended Product Warranty is applicable to the channel cabling solution products only on the original site of installation. Under the Extended Product Warranty, Manufacturer will either repair or replace the defective product itself at Manufacturers' cost. The U.S.A., Manufacturer will pay an Authorized cable installation Reseller for the cost of labor to repair or replace any such defective product on behalf of Manufacturer.
6. Corning Cable Systems LANscape solutions "landscape extended warranty" a 25-year guarantee on complete fiber optic cabling solutions. The telecom contractor shall be an authorized Corning Cabling Systems extended warranty (NPI) installer.

Application Assurance

Application Assurance covers failure of the channel SCS to operate the applications, that the Solution is to support, as well as additional application(s) included in the numbered list. Manufacturer warrants that the registered channel SCS solution will be free from failures which prevent operation of the specific applications for which the original channel SCS was designed. The Application Assurance Program also covers the following additional applications:

1. Those identified in the current (at the time of installation) channel SCS Performance Specifications; and
2. In accordance with application standards specifications, any applications introduced in the future by recognized standards or user forums that use TIA/EIA 568 or ISO/IEC 11801 components and link/channel specifications for cabling.
3. The contractor's certifications are current for the manufacturer's solution installation. The contractor shall provide standards compliant, warranted, end-to-end channel solution for structured cabling solutions.

Additional Warranty

Contractor shall state any additional Contractor supplied warranty. This contractor warrants the Network communications cabling infrastructure system to be free of defects in the materials and workmanship for the period of one year after the date of final payment. The effective date of this warranty applies to all components of these systems regardless of any equipment manufacturer's warranties, which may expire at an earlier date. Any system malfunctions or any previously undiscovered non-compliance with the plans and specifications during the warranty period are repaired at no cost to the Owner are brought into compliance.

Self-Install Warranty: The beyond cat 6 structured cabling manufacturers shall issue The University of North Carolina at Wilmington a Self-Install Warranty for all future moves, adds and changes that are warrantied under this contract document 'Extended product warranty and application assurance program for an end-to-end channel solution'.

Inspection

The Project Manager and/or the SCS System Manager shall perform on-going inspections during construction. All work performed is in a high-quality manner. In addition, the overall appearance shall be clean, neat and orderly. These items need to meet compliance:

1. Is the design documentation complete- Are all the cables properly labeled, from end-to-end?
2. Have all terminated cables been properly tested in accordance with the specifications. Testing includes for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
3. Is the cable type suitable for its pathway? Are the cables bundled in parallel?
4. The manufacturer's pathway Guidelines are used. Is all cable penetrations installed properly and fire stopped according to code?
5. Have the Contractors avoided excessive cable bending?
6. The potential for EMI and RFI sources been considered?
7. Is Cable Fill Ratio Correct?
8. Are hanging supports within 1.5 meters (5 feet)?
9. Does hanging cable exhibit some sag?
10. Are Network communications room terminations compatible with applications equipment?
11. The patch Panel instructions are followed?
12. Jacket removal point.
13. Termination positions.
14. All pair terminations tight with minimal pair distortions.
15. Twists maintained up to Index Strip.
16. The Modular Panel instructions been followed?
 - o Cable dressing first
 - o Jackets remain up to the Connecting Block
 - o All pair terminations tight and undistorted
 - o Twists maintained up to the Connecting Block
17. Connectors are correct side- up in the Jack Panels without cables wrapped or twisted around the Mounting Collars.
18. Are the correct outlet connectors used (T568B)?
19. That the jacket maintained right up to the manufacture specifications.
20. Are identification markings uniform, permanent and readable?

Damages

The contractor is responsible for all damages to portions of the building caused by it, its employees or subcontractors including but not limited to the following:

1. All damage to any [portion of the building caused by the movement of tools, materials or equipment.

2. All damage to any component of the construction of spaces “turned over” to the contractor.
3. All damage to the electrical distribution system and/or other space “turned over” to the contractor.
4. All damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.
5. Other damage to the materials, tools and/or equipment of UNCW, its consultants, General Contractor, subcontractors, Architect, other contractors, agents and leases.

Recorded Documents

Prepare record documents in accordance with the requirements in Division 27 Section “PROJECT CLOSEOUT”. In addition to requirements specified in Division I, indicate installed conditions:

1. Backbone and horizontal cabling, station outlets, layout of ER and TR, all labeling of all cabling, connectors, equipment, conduits, cable trays, etc.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, contract Modifications, and actual equipment and materials installed.

Documentation

The cabling contractor shall provide the following documentation to the owner within 2 weeks following the completion of the installation:

1. Marked up floor plans identifying as-built cable routing for all horizontal backbone cabling. Submitted in electronic format (AutoCAD) and hard copy print out.
2. Marked up floor plans with station outlet identifier listed adjacent to each station outlet. Submitted in electronic format (AutoCAD) and hard copy print out. In addition, the contractor will provide full size laminated prints or framed prints installed by the contractor in each ER and each TR. All required full size drawings installed as required in each TR and ER to reference all station outlets served by a specific ER or TR.
3. Test results for each jack in each station outlet compiled in a binder with the tests listed in numerical order grouped by ER/TR. Provide two CD copies.

4. Tests results for all horizontal and backbone UTP, Co-Ax and fiber cables complied in a binder with the tests grouped by the backbone cable. Provide two 8-1/2 x 11 hardcopies in notebooks and 2 CD copies.
5. A scaled plan of each building showing the placement of each individual item of equipment as well as raceway size and routing, junction boxes, and conductor size, quantity, and color in each raceway.

Quality Assurance

Installers Qualifications: Contractor with a minimum of five years documented successful installation experience on projects utilizing cabling infrastructure work similar to that required for this project. The contractor shall be an experienced firm regularly engaged in the layout and the installation of cabling infrastructure systems. The contractor must be able to show evidence that he has successfully completed projects of similar size and scope in the last 12 months. The contractor shall be a manufacturer certified Business Partner, CVA, or for the TE solution the installers, supervisors, registered certifier, and designers to have a current valid certification card.

1. The Network Communications project manager must have experience in this type of project and he/she expected to provide technical support.
2. The Network Communications project manager shall attend the monthly progress meetings held by the state and additional meetings as scheduled or required.
3. BICSI registration must be current and the installer and technicians must be in good standing.
4. During the shop drawing process, provide copies of all manufacturer and BICSI certifications, the contractor shall meet the following criteria: 15% of work force shall be BICSI certified Technician level or better (RCDD). 15% of work force shall be BICSI certified Installer level 2 or higher; 15% of work force shall be BICSI certified installer level 1 or of equivalent experience/training.
5. Contractor employees will wear visible ID badges on the job site with current picture and company name at all times.

General Requirements

1. Work under this section shall include providing all labor, materials, equipment, and services necessary for and reasonably incidental to the proper completion of all Network communications work as shown on the drawings and herein specified. Work shall also include, but not be limited to the furnishings, unloading, handling, distribution, setting, supporting, and installation of all required components.
2. Refer to electrical drawings for each buildings equipment room, Telecom room (TR) and station outlet location.
3. Refer to the Network communications riser diagrams and diagram drawings for the following:

- a) Outlet elevation: showing all components required for the installation and mounting of the outlet. The faceplate of a typical quad station outlet and all outlet configurations used.
- b) Outlet pathway elevation: shows the details of how the cables routing from the horizontal pathway to the outlet. Conduit size is at a minimum $\frac{3}{4}$ inch stubbed out to within six inches of the cable tray and bonded to the cable tray. In a typical cable tray, voice and data will be located on one side of the cable with the A/V cabling located on the opposite side.
- c) Grounding and bonding drawing: Shows the five major components for the grounding of the Network communications infrastructure throughout the building. The five components shown are the Bonding conductor, the Network communications main grounding bus bar, the Network communications grounding bus bar, the Network communications bonding backbone, Network communications bonding backbone interconnecting bonding conductor. All grounding and bonding shall meet the TIA/EIA –607 standards and the NEC code.
- d) Campus Wide Drawings: Show all details for each individual campus wide access door interior and exterior. Drawings are not to scale. Refer to architectural and structural drawings for building construction and dimensions and to roof finish schedule on architectural drawings for the materials, finish and construction method of walls, floor and ceiling in order to insure proper rough in and installation of work.

Additional Standards and Codes

1. Work to conform with any city, State law, regulation, code, ordinance, and ruling or Fire Underwriters requirement applicable to this class of work.
2. Contractor will comply with the stricter requirement when a conflict occurs.
3. The following guidelines and standards will apply wherever applicable
 - TIA-568-C Commercial Building Standards for Telecommunications
 - TIA- 569-D Commercial Building standards for Pathways and Spaces
 - TIA-606-B Administration (Labeling)
 - TIA- 607-C Grounding and bonding of premises cable
 - BICSI TDMM Telecommunications Distribution Methods Manual
 - BICSI CO-OSP Customer-owned Outside Plant Design Manual
 - ANSI/NECA/BICSI 568-2001

Renovations

The Voice, data, CATV, and AV must be coordinated through Network Communications. A certified contractor for the building solution-SYSTIMAX, NETCONNCET/Uniprise or Belden, does voice, data, CATV, and AV cabling that is in the renovation. Work under this section shall include providing all labor, materials, equipment, and services necessary for and reasonably incidental to the proper completion of all Network communications work as shown on the drawings and herein specified. Work shall also include, but not be limited to the furnishings, unloading, handling, distribution, setting, supporting, and installation of all required components. The contractor will install as-bilts updating all changes in each TR and ER. Electronic copies of the as built will be provided to UNCW project management CAD department. Requirements for projects listed in the standards apply to all renovations involving voice, data, CATV, and AV.

Manholes and Duct banks

1. Seal all ducts at terminations or all conduit entry points with expandable reusable conduit plugs capable of withstanding 15-psi minimum hydro static pressure in manholes and buildings.
2. All duct banks will have a trace wire installed and a 1250-pound tensile test ½ "wide marking cord equivalent to NEPTCO Inc. or MULETAPE part # 1250P.
3. All conduits pulled as full as possible without damage to the cable.
4. All cables secured to the wall of the vault.
5. All cables clearly labeled using stamped aluminum.
6. The labeling for the cables will show destination, origination, cable size and pair count.
7. Cables labeled in all ER, MDF's, and IDF's.
8. Three 11/4-inch ID inner ducts or one four inch 3-cell MaxCell edge. placed in a minimum of one 4-inch conduit leading to every building.
9. The entrance conduit into each building, which contains the inner ducts, shall be equipped with a hole plug designed to seal around each individual inner duct.
10. Each inner duct sealed to prevent leakage into the building.
11. Manhole diagrams and duct bank diagrams shown on the Network communications drawings.
12. Each cable will have a slack loop in each manhole. The slack loop will be one full circle inside the manhole.

13. The distance between manholes should not exceed 450 feet.
14. Manhole lids will be equivalent to a U.S.F. FABRICATION, INC. APD 300.
15. Install conduits with gradual, sweeping elbows and offsets. Hard 90s are not acceptable.
16. Provide non-metallic cable rack on each wall in the manhole with a minimum of three arms each wall.
17. All duct banks inspected and approved prior to the placement of any concrete.
18. Duct bank poured with 3,000-psi concrete and encased all sides with a minimum of three inches.
19. After the duct line is completed, a standard flexible mandrel used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 12 inches long and have a diameter $\frac{1}{4}$ inch less than the inside diameter of the duct being cleaned.
20. A minimum of 2- 4-inch conduits schedule 40 PVC and is required for all Network communications duct banks. Schedule 80 PVC conduit is required for installation under roads and heavy traffic areas.

Joint Trench Required Separations

When a joint-trench method is used, the following vertical or horizontal separations for Network communications facilities and other facilities are used.

Vertical/horizontal separations

Adjacent Structure Minimum Separation

Power or other foreign conduit

- 76 mm (3 in) of concrete, or
- 101 mm (4 in) of masonry, or
- 305 mm (12 in) of well-tamped earth.
- Pipes (gas, oil, water)
- 152 mm (6 inch) when crossing
- 305 mm (12 in) when parallel.
- Street railways 10 mm (3.3 ft.) below top rail.

NOTES: Place cable in rigid PVC conduit for a distance of 3 m (10 ft.) on either side of the pipeline crossing. If multiple pipelines exist, then extend conduit 3 m (10 ft.) from the outside

pipes. Place rigid steel conduit for a minimum distance of 7.6 m (25 ft.) on either side of the center of the track (e.g., rails) crossing. If there are multiple tracks, the conduit should extend out 7.6 m (25 ft.) on either side of the center of the outside tracks.

Confined space Entry Procedures

The purpose of this safe work practice is to provide a procedure when working around an 'open' manhole or preparing to enter a manhole for routine maintenance or inspection. A manhole structure is a confined space that presents possible fall hazards where there is a potential for toxic gases to be present. Therefore, ALL personnel assigned to enter Network Communications manholes shall follow the procedures in this work practice.

Required Safety Equipment and Procedures

All personnel working around open manholes and preparing to enter the manhole shall use the following safety equipment:

1. Approved gas detector (properly calibrated)
2. Fresh air blower;
3. Safety harness, rope, and tripod safety system; and
4. Approved hardhat.

All Network Communications manholes designed for entrance and inspection maintenance on a regular basis use the following procedures before entering the confined space:

1. Atmospheric Testing: Before allowing any personnel inside the confined space, test the space for all three atmospheric conditions, oxygen content, flammable or explosive gases and hydrogen sulfide.
 - a) Oxygen content must be at least 19.5% in the confined space, measured at all levels (bottom, middle, and top). The safe oxygen level is between 19.5% and 21%. Do not enter the confined space if the oxygen level is below 19.5% or above 21%. Due to the extreme danger of suffocation in confined spaces, constant and continuous oxygen monitoring is required throughout each

work period. Oxygen content above 23% can cause explosions or vigorous burning of flammable materials, including hair or clothing.

- b) After you have determined oxygen content, use the detector to measure flammability at all levels of the confined space (bottom, middle, and top). Flammability measured in terms of the Lower Flammable Limit (LFL) or Lower Explosive Limit (LEL). This is the smallest concentration of a combustible gas in air that will explode when it contacts a spark or open flame.
 - c) Finally, test the atmosphere for any toxic concentrations of vapors. Toxicity measured in terms of the Threshold Limit Value (TLV). Use the detector to measure toxicity at all levels of the confined space (bottom, middle, and top). Since toxic concentrations may be lighter or heavier than air, they can be present at the top or the bottom of the confined space. Note: The confined space tested at three levels for each atmospheric condition. Each level tested for a minimum of 60 seconds. The gas detector itself lowered into the confined space atmosphere with a safety line or the detector with an aspirator pump. Consult the detector operating procedures manual if you have any operating questions.
2. Ventilation: A fresh air ventilation system shall be set up and in operation before and during all inspection and maintenance procedures.
 3. After the air ventilation system has been in operation and the confined space has been tested and determined to be safe for entry, the operator shall be equipped with:
 - a) A safety harness and lifeline, attached to the tripod safety retrieval system.
 - b) An approved, properly calibrated gas detector that is in operation the entire time the employee is in the confined space. This is necessary due to the possibility of a rapid change in the confined space atmosphere.
 - c) An approved hard hat.
 4. If permanent ladder steps are not in the confined space, use an aluminum ladder in good operating condition to enter the confined space. Any employee who descends into a man hole/sewer will have safety harness, rope, and tripod safety system attached to the employee.
 5. At least one person stationed above ground for support purposes whenever a confined space is ready for entrance. .
 6. Emergency Action Plan -- No person shall enter a confined space (manhole, to retrieve someone who is unconscious without having additional trained personnel above ground to assist. The person entering the confined space for rescue purposes must be equipped with the required rescue equipment and follow the specific rescue procedure.

7. A qualified person shall inspect all safety devices and instruct all involved employees on proper confined space safety procedures. All defective safety devices reported to the supervisor immediately. It shall be the supervisor's responsibility to insure that crews assigned to enter
8. Confined spaces have the required safety devices in their possession. The supervisor must assure the assigned employee has the required safety devices in their possession. The supervisor must assure the assigned employee trained to operate all safety equipment and understands all safety procedures.

General Manhole Safe Work Practices

1. Use caution when working around manholes.
2. Do not smoke, light open flames, or produce sparks in the immediate vicinity of open manholes.
3. Before removing manhole or entrance covers, test the atmosphere inside the manhole by using remote sampling probe or aspirators. If the lower explosive limit is above 10% inside the manhole, do not remove the cover.
4. Use picks, hooks to open manhole covers.
5. Lift manhole covers and heavy hatches with the legs. Never lift with the back muscles.
6. Lay removed manhole and heavy hatch covers flat on the ground several feet away from the opening.
7. With the manhole or entrance covers removal, the opening requires a railing, temporary cover, or other temporary barrier that will prevent an accidental fall through the opening and protect each employee working in the space from foreign objects entering the space.
8. Use barricades and/or warning devices to direct traffic around open manholes.
9. Follow Public Services Department directions for Confined Space Entry Program and all safety procedures before entering and during entry into any manhole.
10. Have at least two persons present before entering a manhole: One person to enter the manhole and one person in the clear to observe in the event of an emergency. One of the persons must be a "qualified person" as defined by the Public Services Department's Confined Space Entry Program This person bears the responsibility of completing the Confined Space Entry Permit. Never enter a manhole unattended.
11. Wear protective clothing and nonslip, non-sparking shoes in a manhole.
12. Test each individual manhole step carefully. Be sure to check ladder for overall structural soundness and ability to support weight before using.
13. Use ladders to access manholes whenever the structural soundness and support ability of the manhole steps/stairs are in question.
14. Take proper safety precautions when using ladders in a manhole.

15. Use a safety harness and life line when entering a vertical entry manhole, unless the lifeline creates an entanglement hazard.
16. Watch out for slippery footing in a manhole.
17. Do not hand carry tools and/or equipment while climbing up or down steps or a ladder into a manhole.
18. Raise or lower tools and/or equipment into a manhole using a rope, sling, or bucket.
19. Use only explosion-proof portable lighting and non-sparking tools in a manhole.
20. Avoid using electrical tools in or near water. Never stand in water when using electrical tools.
21. Constant ventilation is required when performing "hot-work" within a manhole, if the above safe works, practices is not accomplishable, or if there is a positive reading

Fire Stopping

1. This Section includes requirements for the furnishing and installing of fire rated wiring devices.
2. Furnish and install all fire rated wiring devices and associated hardware as shown on the Contract Drawings and as hereinafter specified.
3. All devices shall be heavy-duty specification grade with an in tumescent insert material allowing for 0 to 100-percent visual fill of conductors.
4. The same manufacturer shall supply all furnished fire rated devices and associated hardware.
5. Fire rated wiring devices shall bear the UL Classification marking.
6. Device testing in accordance with ASTM E 814 (ANSI/UL1479).

Fire rated wiring devices

1. Cables passing through fire-rated floors or walls shall pass through fire-rated wiring devices which contain an in tumescent insert material that adjusts automatically to cable additions or subtractions.

2. The device shall have an F Rating equal to the rating of the barrier in which the device installation is applied.
3. Wiring devices shall be capable of allowing a 0 to 100-percent visual fill of cables.
4. Wire devices shall be of a sufficient size to accommodate the quantity and size of data cables required.
5. Wire devices provided with steel wall plates for single or multiple devices allowing them for joined.
6. Manufacturers' accepted for fire rated devices include Specified Technologies INC., Hilti, and 3M.

Installation

1. Wiring device installation is in locations where drawings indicate on the blue print, and are arranged singly or ganged at the height specified.
2. Install the devices in strict accordance with the approved shop drawings and the equipment manufacturer's recommendations.
3. Apply the factory supplied gasketing material prior to the installation of the wall plates.
4. Secure wall plates to devices per the equipment manufacturer's recommendations.
5. Buildings at UNC-W wiring is according to the established campus –wide wiring standards since the early 1990's. The fire safety considerations of the pathway systems shall comply with all applicable fire safety and electrical codes. In general, the N.C. Department of Insurance determines the compliance of these systems with codes, and reserves the right to inspect and approve/disapprove their installation. If the pathway system is a metallic, enclosed system non-plenum cabling installation within unless otherwise noted. All wireway and conduit penetrations of rated walls and floors shall be fire stopped per applicable UL assembly. Plenum cable installed as required per the guidelines on an individual building basis. UNC-W adheres to the BICSI, NEC, and ANSI/TIA/EIA-569-A guidelines for fire stopping.

Cleaning

1. After the installation is complete contractor shall clean all systems.
2. Vacuum debris from system component, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.
3. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

Codes, Permits, and Fees

1. Comply with all applicable laws, ordinances, rules, regulations, codes, or rulings of governmental units having jurisdiction as well as standards of the National Fire Protection association and serving utility requirements.
2. Obtain and pay for all permits, fees, inspections, utility connections and extensions and the like associated with work in each section of this division.
3. Comply with SCO for inspections as required.

END OF SECTION 27 0000

SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.
 - 4. Grounding labeling.
- B. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. BCT, TMGB, TGBs, and routing of their bonding conductors.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently registered by BICSI as a RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with latest TIA-607 standard.

2.2 CONDUCTORS

- A. Manufacturers:
 - 1. Panduit Corporation
 - 2. The Siemon Company
 - 3. Harger Lightning & Grounding.
 - 4. Tyco Electronics Corp.
 - 5. Burndy; Part of Hubbell Electrical Systems
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Cable Tray Equipment Grounding Wire: No. 6 AWG.
- D. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

- A. Manufacturers:

1. Panduit Corporation
 2. The Siemon Company
 3. Harger Lightning & Grounding.
 4. Tyco Electronics Corp.
 5. Burndy; Part of Hubbell Electrical Systems
- B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

- A. Manufacturers:
1. Chatsworth
 2. Approved Equal
- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with latest TIA-607 standard.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with latest TIA-607 standard.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.

3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with latest TIA-607 standard. Predrilling shall be with holes for use with lugs specified in this Section.
 1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 2. Rack-Mounted Vertical Busbar: 72-inch long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 IDENTIFICATION

- A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with latest TIA-607 standard.

3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2 AWG minimum.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.
- D. Conductor Support:
 - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- E. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch intervals.
 - 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 60 inches above finished floor unless otherwise indicated.
- B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.6 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - 1. Use crimping tool and the die specific to the connector.
 - 2. Pretwist the conductor.
 - 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the TMGB with insulated bonding conductor.
- E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.
- H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.
- I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.

- J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
- K. Access Floors: Bond all metal parts of access floors to the TGB.

3.7 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 - 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
 - 3. Label the BCT and each telec.mmunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 - 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.

- C. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 27 0526

SECTION 27 0536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Runway ladder cable tray.
 - 2. Cable tray accessories.
 - 3. Warning signs.
- B. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - 2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above (Minimum 12") and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
- B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Structural Performance: See articles on individual cable tray types for specific values for uniform load distribution, concentrated load, and load and safety factor parameters.

2.2 RUNWAY LADDER CABLE TRAY

- A. Manufacturers:
 - 1. Legrand: 09-8104-Length-12-BK
 - 2. Eaton B-Line
 - 3. Snake Tray: 610 Series
 - 4. MonoSystems
 - 5. Middle Atlantic: CLB Series
- B. Description:
 - 1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
 - 2. Minimum Width: 12 inches unless otherwise indicated on Drawings.
 - 3. Minimum Usable Load Depth: 1 inch.
 - 4. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
 - 5. Rung Spacing: 9 inches o.c.
 - 6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
 - 7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
 - 8. No portion of the rungs shall protrude below the bottom plane of side rails.
 - 9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - 10. Fitting Minimum Radius: 12 inches.
 - 11. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - 12. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
- C. Materials and Finishes:

1. Steel

2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

- A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."
- B. Lettering: 1-1/2-inch high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.5 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Fasten cable tray supports to building structure.
- D. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."

- E. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- F. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
- G. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
- H. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- I. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- J. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
- K. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with hook and loop straps. Nylon cable tie wraps are not acceptable. Bundle sizes shall not exceed 24 cables each.
- C. Fasten cables on vertical runs to cable trays every 18 inches.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables

independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

- E. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

- A. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections.
 - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
 - 4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
 - 5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - 7. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 8. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
- B. Prepare test and inspection reports.

3.6 PROTECTION

- A. Protect installed cable trays and cables.

END OF SECTION 27 0536

SECTION 27 0553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

- B. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.2 ACTION SUBMITTALS

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

B. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and latest TIA 606 standard.
- B. Comply with ANSI Z535.4 for safety signs and labels.

- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 - 1. Black letters on a white field.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible labels with acrylic pressure-sensitive adhesive.
 - 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 - 2. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 SIGNS

- A. Baked-Enamel Signs:

1. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.

B. Laminated-Acrylic or Melamine-Plastic Signs:

1. Engraved legend.
2. Thickness:
 - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. in., 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Self-adhesive.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.5 CABLE TIES

A. Manufacturers:

1. Panduit
2. Velcro
3. Rip-Tie

B. Hook and Loop Cable Ties:

1. Minimum Width: 1/2 inch.
2. Minimum Tensile Strength: 40 lbs.
3. Flammability Rating: UL94 V-2
4. Temperature Range: 0°F to 122°F
5. Color: Black.
6. Utilize in Spaces Handling Environmental Air

C. Hook and Loop Cable Ties:

1. Minimum Width: 3/4 inch.
2. Minimum Tensile Strength: 50 lbs.
3. Temperature Range: 0°F to 220°F
4. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Verify identity of each item before installing identification products.
- C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- F. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- G. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - 3. Provide label within 3 to 6 inches from cable end.
- H. Snap-Around Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label within 3 to 6 inches from cable end.
- I. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label within 3 to 6 inches from cable end.
- J. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

3.2 IDENTIFICATION SCHEDULE

- A. Administration Class: [Class 1] [Class 2] [Class 3] [Class 4]. Include optional identification requirements of this standard. Administration Class applies project wide.
- B. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- C. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
 - 1. System legends shall be as follows:
 - a. Telecommunications.
 - b. **<Insert name>**.
- E. Equipment Room Labeling:
 - 1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
 - 2. Patch Panels Label individual rows and outlets, starting at to left and working down, with self-adhesive labels.
 - 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.
 - b. Colon.
 - c. Faceplate number.
- F. Backbone Cables: Label each cable with a self-adhesive wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identicallyCable numbering shall follow the example:
 - 1. U.T.F.XXX
 - a. U = D for data or V for voice
 - b. T = Network Communications Room Number
 - c. F = Floor Number
 - d. XXX = Unique identifier between 0 and 999 denoting cable number
 - 1) Example: CABLE D.5.2.013
 - 2.

- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
1. Room number.
 2. Colon.
 3. Faceplate number.
- H. Cable numbering shall follow the example:
1. U.T.F.XXX
 - a. U = D for data or V for voice
 - b. T = Network Communications Room Number
 - c. F = Floor Number
 - d. XXX = Unique identifier between 0 and 999 denoting cable number
- 1) Example: CABLE D.5.2.013
- I. Instructional Signs: Self-adhesive labels.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: **[Self-adhesive labels] [Baked-enamel warning signs]**.
1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
1. Indoor Equipment: **[Self-adhesive label] [Baked-enamel signs] [Laminated-acrylic or melamine-plastic sign]**.
 2. Outdoor Equipment: **[Laminated-acrylic or melamine-plastic sign]**.
 3. Equipment to Be Labeled:
 - a. Communications cabinets.
 - b. Uninterruptible power supplies.
 - c. Computer room air conditioners.
 - d. Fire-alarm and suppression equipment.
 - e. Egress points.
 - f. Power distribution components.
- L. Rack- mounted 110-block labeling: Each 110-block position (each 4-pair connector clip) will be labeled as follows:
1. Standard SOs/ wall phones outlets FVXX
 - a. FVXX = SO identifier where the Category 6 or beyond Category 6 cable on that connector clip terminates
- M. Modular patch panel labeling: Each panel has labeling. Each modular jack panel position shall be XXX where XXX matches the SO identifier. The patch panel shall have a label placed on the

upper left-hand corner of the panel face identifying the panel. All labels for the labeling printed using a computer, printer or Brother p-touch labeler with the TZ tape or equivalent. LABELS SHALL NOT BE HANDWRITTEN. Labels shall be different colors as detailed for identification per the 606B standard. The contractors shall meet with UNCW Telecom personnel, verify the numbering schemes, and label coloring

N. Station outlet labeling consists of two components:

1. Top faceplate label
2. Bottom faceplate label.
3. The label will consist of a five-character identifier with the format F-Y-XXX
 - a. F = Floor number of the building
 - b. Y = D for data or V for voice
 - c. XXX = Unique identifier between 0 and 999 for any station outlet on that floor served by the same ER/TR.

1) Example: 2-D-013

O. Faceplate labels for wall phones:

1. Will consist of 4-character identifier with the format F-V-XX.
 - a. F = Floor number
 - b. V = Denoting Voice
 - c. XXX = Unique identifier between 0 and 99.

1) Example: 2-V-12

P. Wireless access point labeling:

1. Label the grid work at the outlet location with a printed label.
2. Provide WAP in front of the horizontal cable label at the rack end.
3. A green dot on the grid work is for easy location identification.

a. Example: WAP D.5.2.013

Q. Cable numbering shall follow the example:

1. U.T.F.XXX
 - a. U = D for data or V for voice
 - b. T = Network Communications Room Number
 - c. F = Floor Number
 - d. XXX = Unique identifier between 0 and 999 denoting cable number

1) Example: CABLE D.5.2.013

END OF SECTION 27 0553

SECTION 27 1116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 19-inch equipment racks.
2. 19-inch equipment cabinets.
3. Power strips.

- B. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.2 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 3. Detailed Rack Elevations indicating layout of equipment. Coordinate with ITS department.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD.
 - 2. Installation Supervision: Installation shall be under direct supervision of Technician, who shall be present at all times when work of this section is performed at project site.
 - 3. Field Inspector: Currently registered by BICSI as RCDD to perform on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. UL listed.
- B. RoHS compliant.

2.2 19-INCH EQUIPMENT RACKS

- A. Description: Two post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting.
- B. Manufacturers:
 - 1. Panduit
 - 2. Chatsworth
 - 3. Great Lakes
 - 4. Siemon
 - 5. Middle Atlantic
 - 6. Ortronics
- C. General Requirements:
 - 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Aluminum (Two-Post).
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.

4. Color: Black.

D. Floor-Mounted Racks:

1. Overall Height: 84 inches
2. Overall Width: 19 inches
3. Two-Post Load Rating: 1000 lb
4. Number of Rack Units per Rack: 45
 - a. Numbering: Every rack unit, on interior of rack.
5. Threads: 12-24.
6. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
7. Base shall have a minimum of four mounting holes for permanent attachment to floor.
8. Top shall have provisions for attaching to cable tray or ceiling.
9. Self-leveling.

E. Wall-Mounted Racks:

1. Height: As indicated on Drawings.
2. Depth: 24 inches
3. Load Rating: 150 lb
4. Number of Rack Units per Rack: As indicated on Drawings.
5. Threads: 12-24.
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Dual hinges open to right or left, stopping in 90° position.

F. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. 6-inch-wide x 6 inch deep vertical cable management panels with front and rear channels and removable covers.
4. Each 2-post rack will have a vertical cable manager per side. If two (2) racks are side by side the total vertical cable manager's width will be twelve (12) inches wide.
5. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.3 19-INCH EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting.

B. Manufacturers:

1. Panduit
2. Chatsworth
3. Great Lakes
4. Siemon
5. Middle Atlantic
6. Ortronics

C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: Aluminum.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.

D. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Vertical cable management panels shall be a minimum of 6" wide and 6" deep.
5. Each rack will have vertical cable managers on each side of said rack.
6. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Vertically rack mounted with 6-inch standoffs on back of rack.
3. Length: 6 ft.
4. Housing: Metal.
5. (14) 120-VAC, 5-20R Receptacles.
6. LED indicator lights for power and protection status.
7. LED indicator lights for reverse polarity and open outlet ground.
8. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
9. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
10. Cord connected with 15-foot line cord.
11. Rocker-type on-off switch
12. Surge Protection: UL 1449, Type 3.

- a. Maximum Surge Current, Line to Neutral: 72 kA.
- b. Protection modes shall be line to neutral, line to ground, and neutral to ground.
- c. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall be 600 V and 500 V for neutral to ground.

2.5 PLYWOOD BOARD

- A. $\frac{3}{4}$ " non-fire rated plywood
 1. Line all walls of telecommunications rooms with plywood
 2. Mount 4" above finished floor
 3. Plywood boards shall be 4' Wide x 8' Tall.
 4. Paint with (2) coats of fire intumescent white paint.
 - a. Paint shall be free of blemishes and footprints.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with TIA-568B-C and TIA-569.
- C. Comply with BICSI TDMM for layout of communications equipment spaces.
- D. Comply with BICSI ITSIMM for installation of communications equipment spaces.
- E. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- F. Mount all wall mounted equipment securely to plywood board.
- G. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.
 1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.
 3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.

- 4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- H. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

END OF SECTION 27 1116

SECTION 27 1313 - COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 5e twisted pair cable.
2. Category 6 twisted pair cable.
3. Twisted pair cable hardware, including plugs, jacks, patch panels, and cross-connects.
4. Grounding provisions for twisted pair cable.
5. Cabling identification products.
6. Source quality control requirements for twisted pair cable.

1.2 COPPER BACKBONE CABLING DESCRIPTION

- A. Copper backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.
- C. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. Cabling administration Drawings and printouts.
 3. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.

- c. Telecommunications system access points.
 - d. Telecommunications grounding system
 - e. Cross-connects.
 - f. Patch panels.
 - g. Patch cords.
 - 4. Cross-Connects and Patch Panels: Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 - C. Twisted pair cable testing plan.
- 1.4 INFORMATIONAL SUBMITTALS
- A. Source quality-control reports.
 - B. Field quality-control reports.
 - C. Product Certificates: For each type of product.
- 1.5 CLOSEOUT SUBMITTALS
- A. Maintenance data.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of shop drawings, cabling administration drawings, and field testing program development by an RCDD.
 - 2. Installation: Installer shall be manufacturer certified to install cabling system submitted.
 - 3. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when work of this section is performed at project site.
 - 4. Testing Supervisor: Currently certified by BICSI as a RCDD to supervise on-site testing.
 - B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.
- 1.7 COORDINATION
- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications Plenum Rated: Type CMP complying with UL 1685
 - 2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - 3. Communications Riser Rated: Type CMR complying with UL 1666.
 - 4. Communications Riser Rated: Type CMP or Type CMR in listed plenum or riser communications raceway.
 - 5. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
- C. RoHS compliant.

2.3 OUTSIDE PLANT CABLE (PE-89)

- A. Description: 100-ohm, 23 AWG, four unshielded twisted pairs (UTP)
- B. Standard: Comply with TIA-758-B for Customer-Owned Outside Plant Telecommunications Infrastructure.
- C. General Requirements for Cable Connecting Hardware:
 - 1. Twisted pair cable hardware shall meet the performance requirements of Category 6
 - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - 3. Cables shall be terminated with connecting hardware of same category or higher.

4. Source Limitations: Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.
- D. Connecting Blocks: 110-style IDC for Category 3. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.
- E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
- F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 3. Number of Jacks per Field: One for each four-pair cable indicated
- G. Plugs and Plug Assemblies:
 1. Male; eight position (8P8C); color coded modular telecommunications connector designed for termination of a single four-pair 100 ohm unshielded or shielded twisted pair cable.
 2. Standard: Comply with TIA-568-C.2.
 3. Marked to indicate transmission performance.
- H. Jacks and Jack Assemblies:
 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable.
 2. Designed to snap-in to a patch panel or faceplate.
 3. Standard: Comply with TIA-568-C.2.
 4. Marked to indicate transmission performance.
- I. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with an eight-position modular plug at each end.
 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

2. Patch cords shall have color-coded boots for circuit identification.

2.4 SOURCE QUALITY CONTROL

- A. Factory test cables on reels according to latest TIA-568-C.1 standard.
- B. Factory test cables according to latest TIA-568-C.2 standard.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal all raceway, except where not possible in unfinished mechanical/electrical spaces.
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install cables parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."
- C. Comply with Section 270529 "Hangers and Supports for Communications Systems."
- D. Comply with Section 270536 "Cable Trays for Communications Systems."
- E. Drawings indicate general arrangement of pathways and fittings.

3.4 INSTALLATION OF COPPER BACKBONE CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI's "Information Transport Systems Installation Manual," Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI's "Information Transport Systems Installation Manual," Ch. 6, "Cable Termination Practices." Use lacing bars and distribution spools.
 - 9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 11. In the communications equipment room, install a minimum 10-foot long service loop unless otherwise noted.
 - 12. Pulling Cable: Comply with BICSI's "Information Transport Systems Installation Manual," Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
 - 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Installation of Cable Routed Exposed under Raised Floors:
 - 1. Install cabling after the flooring system has been installed in raised floor areas.
 - 2. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
 - 1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and latest TIA-569 standard for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 - 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
 - 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 - 4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
 - 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
 - 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with latest TIA-569 standard, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.6 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with latest TIA-607 standard and NECA/BICSI-607.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with latest TIA-606 standard. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
 - 1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Cable and Wire Identification:
 - 1. Label each cable within 6 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 150 feet.
 - 3. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.
 - 4. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- C. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with latest TIA-606 standard requirements for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

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

- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative.
- E. Tests and Inspections:
 - 1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
- G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- H. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- I. Prepare test and inspection reports.

END OF SECTION 27 1313

SECTION 27 1323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. 9/125 micrometer single-mode, indoor-outdoor, tight buffered optical fiber cable (OS1).
 - 2. 9/125 micrometer single-mode, indoor-outdoor, loose tube optical fiber cable (OS2).
 - 3. Optical fiber cable connecting hardware, patch panels, and cross-connects.
 - 4. Cabling identification products.

1.2 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

- A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.
- C. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration drawings and printouts.
 - 4. Wiring diagrams to show typical wiring schematics including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.

- d. Telecommunications grounding system
- e. Cross-connects.
- f. Patch panels.
- g. Patch cords.

5. Cross-connects and patch panels.

C. Optical fiber cable testing plan.

D. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Product Certificates: For each type of product.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of shop drawings, cabling administration drawings, and field-testing program development by an RCDD.
 - 2. Installation: Installer shall be manufacturer certified to install cabling system submitted.
 - 3. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when work of this section is performed at project site.
 - 4. Testing Supervisor: Currently certified by BICSI as a RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.7 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: [50] [450] or less.
- C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- D. Grounding: Comply with TIA-607-B.

2.2 9/125 MICROMETER SINGLE-MODE, INDOOR-OUTDOOR, TIGHT BUFFERED OPTICAL FIBER CABLE (OS1)

- A. Description: Single mode, 9/125-micrometer, [unarmored] [armored] tight buffered, optical fiber cable.
- B. Manufacturers:
 - 1. Corning Cable Systems: Model Series
 - 2. Manufacturer #2: Model Series
 - 3. Manufacturer #3: Model Series
- C. Standards:
 - 1. Comply with TIA-492CAAA for detailed specifications.
 - 2. Comply with TIA-568-C.3 for performance specifications.
 - 3. Comply with ICEA S-104-696 for mechanical properties.
- D. Armored cable shall be aluminum armored type.
- E. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: Yellow
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, armored (Conductive): Type OFCP, complying with NFPA 262.
9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Armored (Conductive): Type OFCR ; complying with UL 1666
12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.3 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR, LOOSE TUBE OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, [unarmored] [armored] loose tube, optical fiber cable.

B. Manufacturers:

1. Corning Cable Systems
2. Panduit
3. Leviton

- C. Standards:
 - 1. Comply with TIA-492CAAB for detailed specifications.
 - 2. Comply with TIA-568-C.3 for performance specifications.
 - 3. Comply with ICEA S-104-696 for mechanical properties.
- D. Armored cable shall be aluminum armored type.
- E. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.
- F. Jacket:
 - 1. Jacket Color: Yellow
 - 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.
- G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - 2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
 - 3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
 - 4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 - 5. Riser Rated, Nonconductive: Type OFNR complying with UL 1666.
 - 6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
 - 7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - 8. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
 - 9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
 - 10. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - 11. Riser Rated, Armored (Conductive): Type OFCR complying with UL 1666
 - 12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
 - 13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.4 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers:

1. Corning Cable Systems: Model Series
2. Panduit
3. Leviton

B. Standards:

1. Comply with Optical Fiber Connector Intermateability Standard specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

C. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

D. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

E. Connector Type: Type LC complying with TIA-604-10-B connectors.

F. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 dB.
3. Marked to indicate transmission performance.

G. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

2.5 IDENTIFICATION PRODUCTS

A. Comply with latest TIA-606 standard and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.6 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
- C. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal all raceway, except where not possible in unfinished mechanical/electrical spaces.
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- C. Fiber optic cable splicing is unacceptable for any fiber optic cabling: outside plant or intra-building.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.
- B. General Requirements for Optical Fiber Cabling Installation:
 - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a minimum 10-foot long service loop unless otherwise noted.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install cabling after the flooring system has been installed in raised floor areas.
2. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.5 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

- B. Comply with latest TIA-607 standard and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
 - 1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-B.
- C. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for cable and asset management software.
- D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- F. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Label each unit and field within distribution racks and frames.
 - 4. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.

Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

- G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Tests and Inspections:
1. Each 62.5 OR 50/125-micron fiber will be tested patch panel to patch panel at the 850 and 1300 nm wavelength in both directions using a light meter.
 2. Each single mode fiber will be tested patch panel to patch panel at the 1310 and 1550 nm wavelength both directions using a light meter.
 3. The maximum total attenuation for any single fiber between patch panels will not exceed 2.0 db.
 4. Power meter tests: For building risers, power meter tests are required.
 5. Provide a power test and OTDR test for length, attenuation, and micro bends for each individual fiber.
 6. Documentation will include the power test, OTDR results, and all other test results.
 7. Link attenuation does not include any active devices or passive devices other than cable connectors and splices.
 8. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
 9. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 10. Optical Fiber Cable Tests:

- a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- b. Test instruments shall be recently calibrated to manufacturers standards.
- c. Test instruments shall be updated to manufacturers most recent firmware.
- d. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
 - 2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.
- D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- E. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
- F. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 27 1323

SECTION 27 1513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 6 twisted pair cable.
2. Category 6A twisted pair cable.
3. Twisted pair cable hardware, including plugs and jacks.
4. Cable management system.
5. Grounding provisions for twisted pair cable.

1.2 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 sq. ft and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.
- D. Refer to 270000 UNCW ITS Infrastructure Standards for Installation for additional information. Information contained in 270000 shall take precedence.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration Drawings and printouts.
 - 4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

- C. Twisted pair cable testing plan.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of shop drawings, cabling administration drawings, and field-testing program development by an RCDD.
 - 2. Installation: Installer shall be manufacturer certified to install cabling system submitted.
 - 3. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when work of this section is performed at project site.
 - 4. Testing Supervisor: Currently certified by BICSI as a RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as a RCDD.

1.7 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway.
 - 2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 450 or less.
- C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
- B. Manufacturers:
 - 1. CommScope SYSTIMAX GigaSPEED XL
 - 2. CommScope NETCONNECT/Uniprise CS37
 - 3. Belden 2412

- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP)
- F. Jacket Colors:
 - a. Category 6 Data – Blue (Unless otherwise noted on plan)
 - b. Category 6 Telecommunications Voice – White
 - c. Category 6 Wireless Access Points - Purple

2.4 CATEGORY 6A TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6A cable at frequencies up to 500MHz.
- B. Manufacturers:
 - 1. CommScope SYSTIMAX GigaSPEED X10D - x91B
 - 2. CommScope NETCONNECT/Uniprise CS47
 - 3. Belden 10GXS
 - 4. Belden 2400 System (2412)
- C. Standard: Comply with TIA-568-C.2 for Category 6A cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP)
- F. Jacket Colors:
 - a. Category 6A Data – Blue (Unless otherwise noted on plan)
 - b. Category 6A Telecommunications Voice – White
 - c. Category 6A Wireless Access Points - Purple

2.5 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers:
 - 1. Belden REVConnect
 - 2. Belden KeyConnect
- C. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 6 and Category 6A respectively.
 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.
- E. Connecting Blocks:
1. 110-style IDC or GigaBIX for Category 6.
 2. 110-style IDC or GigaBIX for Category 6A.
 3. Provide blocks for the number of cables terminated on the block, plus 25% spare, integral with connector bodies, including plugs and jacks where indicated.
- F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.
- G. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 3. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.
- H. Patch Cords: Factory-made, four-pair cables terminated with an eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
 2. Patch cords shall have color-coded boots for circuit identification.
 3. Lengths by type:
 - a. WAO (Work Area Outlets): 50% 15 feet, 50% 20 feet. Unless otherwise designated by the Network communications department. The quantity for the Work area outlets will be for all Network communications data outlets throughout the facility.
 - b. Data Racks: 40% 2 feet, 40% 3 feet, and 20% 4 feet.

- c. WAPs (Wireless Access Points): minimum of 5 feet and the quantity is for each wireless access point.
- 4. All patch cords to be included in the data cable quantity.
- I. Plugs and Plug Assemblies:
 - 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Standard: Comply with TIA-568-C.2.
 - 3. Marked to indicate transmission performance.
- J. Jacks and Jack Assemblies:
 - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Jack Colors:
 - a. Category 6 Data – Yellow
 - b. Category 6 Telecommunications Voice - White
 - 3. Designed to snap-in to a patch panel or faceplate.
 - 4. Standard: Comply with TIA-568-C.2.
 - 5. Marked to indicate transmission performance.
 - 6. Belden copper systems, jacks and modular plugs shall be from Belden's Key Connect & REVConnect product family. REVConnect is only for WAP locations.
- K. Faceplate:
 - 1. Shall match adjacent receptacle material and finish. Coordinate with Architect.
 - 2. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - 3. Work Area Outlet (WAO) faceplate is white with a minimum of four ports with label insert top and bottom.
- L. Legend:
 - 1. Machine printed, in the field, using adhesive-tape label.
 - 2. Snap-in, clear-label covers and machine-printed paper inserts.

PART 3 - EXECUTION

3.1 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal all raceway, except where not possible in unfinished mechanical/electrical spaces.

- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.
- D. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.1.
 - 2. Comply with BICSI's Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 - 9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - 10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 11. In the communications equipment room, install a minimum 10-foot long service loop unless otherwise noted.
 - 12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
 - 1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.

3.2 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.3 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with latest TIA-607 standard and NECA/BICSI-607.

3.4 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Paint and label colors for equipment identification shall comply with TIA-606-B.
- C. Equipment grounding conductors.
- D. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.
 - 4. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

- E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

- 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections:
 - 1. Test instruments shall be recently calibrated to manufacturers standards.
 - 2. Test instruments shall be updated to manufacturers most recent firmware.
 - 3. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
 - 4. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 5. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
- D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 WARRANTY

- A. Cable Manufacturer shall warranty cabling and cabling hardware for a 20-year period.

END OF SECTION 27 1513

SECTION 27 53 19 - EMERGENCY RESPONDER RADIO ANTENNA/REPEATER SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish, install, and test a complete and operating Emergency Responder Radio Antenna/Repeater System.

1.02 SECTION INCLUDES

- A. This Section includes the requirements for an Emergency Responder Radio Antenna/Repeater System for the purposes of assuring reliable communications by providing a minimum signal strength and minimum voice quality in 95% of all areas of the building.
- B. Components Include
 1. Bi-directional amplifiers ("BDA" or "BDAs")
 2. Donor antenna
 3. Indoor coverage antennas
 4. Distributed Antenna System ("DAS")
 5. Coaxial cable
 6. Splitters and directional couplers
 7. Backup power
 8. All other equipment and components necessary for a complete and functioning Emergency Responder Radio Antenna/Repeater System.

1.03 RELATED CODES AND STANDARDS

- A. All aspects of system design, installation, testing and maintenance shall comply with the current versions of the following:
 1. NFPA 1 – The National Fire Code (including Annex O from 2009)
 2. NFPA 70 – The National Electrical Code
 3. NFPA 101, Life Safety Code
 4. NFPA 72-07 National Fire Alarm Code
 5. FCC 47 CFR Part 90.219: Private Land Mobile Radio, Use of Signal Boosters
 6. Section 510 International Fire Code
 7. TSB-88-B, The Telecommunications Industry Association's (TIA) Technical Service Bulletin 88
 8. Equipment manufacturers' installation and maintenance specifications
- B. The requirements established by the AHJ in effect at the time of system installation supersede the specifications in this section. It is the contractor's responsibility to assure the installed system complies with all currently applicable local, national and industry codes as adopted by the AHJ.

1.04 DEFINITIONS

A. Definitions:

1. Authority Having Jurisdiction (“AHJ”): The local authority responsible for establishing requirements for Emergency Responder Radio Coverage Systems consistent with local codes and policies.
2. Critical Areas: Spaces within a building that require an extra assurance of radio coverage. These areas include emergency command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets and other areas deemed critical by the AHJ.
3. Contractor: The entity bidding the project.
4. Owner: The entity who commissioned the project and will own the finished building.
5. Bi-Directional Amplifier or “BDA”: An electronic device designed to provide amplification of uplink and downlink channels of radio services. These devices can be configured for operation on specific narrow-band frequencies, on a specific frequency band or on multiple frequency bands.
6. Distributed Antenna System (“DAS”): A network typically consisting of coaxial cable, fiber cable, splitters, taps, couplers and antennas designed for delivering radio signals to and from spatially separated antenna nodes or other intentional radiators, such as leaky coaxial cable, within a building or area where traditional off-air signal delivery is compromised.
7. Backup Power Supply: A secondary power source to support uninterrupted system operation in case of a failure of the primary power source. This system is configured to automatically transfer its load upon failure and restoration of the primary power source.
8. Donor Antenna: An antenna installed and directed to intercept over-the-air downlink and uplink radio signals on one or more channels from a specific base station or fixed repeater facility. A donor antenna usually is located on a roof or other location where reliable signal reception can be achieved. This antenna conveys radio signals delivered to and from a distributed antenna system.
9. Emergency Responder Radio Coverage System: A two-way radio communication system installed to assure the effective operation of radio communications systems specifically for fire, emergency medical services or law enforcement agencies within a structure where radio reception may otherwise be too weak for reliable communications.
10. Delivered Audio Quality Definitions (“DAQ”): This is a universal standard adopted from TSB-88-B and often cited in system designs and specifications.
 - a. DAQ 1: Unusable, speech present but unreadable.
 - b. DAQ 2: Understandable with considerable effort. Frequent repetition due to noise/distortion.
 - c. DAQ 3: Speech understandable with slight effort. Occasional repetition required due to noise/distortion.
 - d. DAQ 3.4: Speech understandable with repetition only rarely required. Some noise/distortion
 - e. DAQ 4: Speech easily understood. Occasional noise/distortion.
 - f. DAQ 4.5: Speech easily understood. Infrequent noise/distortion.
 - g. DAQ 5: Speech easily understood.

11. Active System Components: System components, such as amplifiers, that require power. These components typically are utilized to provide amplification or “gain” to signals on the system.
12. Passive System Components: These components introduce signal loss in an RF system. Splitters, combiners, taps, directional couplers and cable are examples of passive system components.
13. Passive InterModulation (“PIM”): Unwanted signals generated due to non-linear connections or junctions in an RF path.
14. FCC: Federal Communications Commission
15. OET 65 Standards: FCC's Bulletin 65 provides Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.
16. Public Safety/First Responder: Public Safety or First Responder agencies which are charged with the responsibility of responding to emergency situations. These include, but are not limited to: law enforcement departments, fire departments, and emergency medical companies.
17. RF: Radio Frequency

1.05 Design Approval

Plans shall be submitted and approved by the AHJ prior to installation. The Owner will submit the proposed design along with the full building plans as part of its Scheduled Plan Review. The following information shall be provided by the system designer/Contractor:

1. Detailed drawings showing the location of the amplification equipment and associated antenna systems.
 - a. System Block Diagram including the donor antenna(s), BDA(s), passive components and in-building antennas. Include the RF link budget.
 - b. Overlay of the system design on building floor plan drawings
2. Manufacturer's data sheets on all equipment to be installed.

1.06 PERFORMANCE REQUIREMENTS

A. Frequencies

1. *Two* sets of frequencies are to be utilized on the system.
2. The following FCC-licensed facilities are to be carried on the system:

FCC Call Sign	Downstream/ Base-to-mobile	Upstream/ Mobile-to-base	Channel
	Frequency	Frequency	Bandwidth

3. Transmissions on each set of frequencies must individually meet the coverage, minimum signal and minimum voice quality requirements.
4. Frequency Changes: Equipment selected for this system must be capable of being configured to different frequency pairs in the Public Safety frequency bands. These changes may later be necessary due to future additions or optimization of radio systems maintained by the AHJ.
5. It is the responsibility of the contractor to confirm the frequencies in use with the AHJ before proceeding with the system installation.

B. Minimum Received Signal Levels

1. Downstream signals: -95 dBm; The minimum signal strength that shall be received inside the building.
2. Upstream signals: -95 dBm: The minimum signal strength that shall be received at the Authority's repeater site.
3. Received signals in the building and at the Authority's repeater facility shall have a minimum Signal-to-Noise ratio of 15 dB.
4. Minimum received signal levels must be maintained regardless of seasonal and occasional signal path propagation conditions including those caused by weather and seasonal foliage changes.
5. Donor antennas utilized for the system must be directional and directed toward the respective repeater(s).
6. The minimum isolation between the donor antenna and system antennas shall be 15 dB or higher as necessary to prevent system oscillation based on the operating parameters required to meet the minimum coverage requirements.

C. Coverage

1. Signals at or above the minimum levels are to be receivable to and from 95% of all areas within the building. Spaces or rooms defined as critical areas require 99% coverage. For purposes of this Section, 95% coverage is considered to be all areas of the building.
2. The contractor is responsible for providing a system design and installation that provides enhancement only to those areas of the building where existing off-air service does not meet the minimum levels as described above. Signal strength surveys to confirm coverage enhancement requirements are the responsibility of the contractor. Care must be taken in engineering a system that will not cause interference to the Authority's radio system outside the building.

D. Equipment Locations

1. BDA: Wall space has been allocated for system electronic and headend components in the upper level Telecommunication Room (I.T.), (T.R.). The wall space is 4 feet wide by 8 feet tall.
2. Donor Antenna(s): A preferred antenna location on the building roof has been specified by the owner. The contractor is responsible for providing and installing the antenna(s), mounting hardware, roof penetration and conduit from the antenna mast to the Fire Control Room. Provide a 4" conduit from the room housing the BDA to the roof. At the roof level provide a weather-head on the conduit. Coordinate roof penetrations and sealing with the General Contractor.
3. Electronic components, including secondary power, shall be designed for operation in a NEMA 4 non-vented weather tight box. These components must be capable of reliable operation at temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C) minimum.

E. System Power Source

1. A dedicated, 120-volt, 20 A circuit has been specified as primary power for the BDA or any other required electronic components located in the Telecommunication Room (I.T.), (T.R.). If additional power is required at this or other locations such must be clearly specified as part of the submitted system design. The electrical contractor shall include the cost of additional power sources in the bid.
2. A secondary automatic transfer power source for all active electronic components in the system shall be provided. Supplier shall provide battery back-up for 24 hours of

operation minimum. When the back-up system includes a generator, provide a UPS to support the 100 percent operation of the system for a minimum of two (2) hours. The emergency generator system serves the UPS system and shall provide power to the UPS system for a minimum of 24 hours. If the back-up system does not include a generator provide a UPS system to support the 100 percent operation of the system for a minimum of twenty-four (24) hours.

F. Mode of Operation

The system shall be designed for continuous, always-on service. A malfunction alarm for the BDA shall be provided and connected to the building fire alarm system.

G. System Frequency Response

All cable and passive electronic components shall have a minimum pass band of 400 – 2700 MHz. Systems that utilize a higher band, 698-2700 MHz shall be permitted if the band falls within that range.

H. Survivability

1. Physical Protection: All wiring and cabling, with the exception of radiating cable and antenna jumper cables measuring less than 2 feet in length, shall be installed in conduit.
2. All exposed cable, including flexible jumper cables, shall be plenum rated, utilizing a jacket of non-halogenated, fire retardant polyolefin.
3. Survivability levels shall be verified with local AHJ prior to construction. A survivability level of 2 (2 hour rated cabling) is required unless otherwise indicated by the AHJ.

I. Compatibility

Provide class-A BDA.

J. RF Exposure

The system shall meet the RF exposure guidelines of FCC Bulletin OET 65.

1.07 SUBMITTALS

A. Submittal Requirements with Bid Response

1. Product Data: Submit the manufacturer datasheets for the following components:
 - a. Donor Antennas
 - b. Coverage Antennas and/or Radiating Cable
 - c. Coaxial Cable and Connectors
 - d. Passive Devices including Splitters, Taps, Combiners and Couplers
 - e. Bi-Directional Amplifiers (BDA)
 - f. Secondary Power Supplies
 - g. Surge Protection
2. Shop Drawings
 - a. System Block Diagram including the donor antenna(s), BDA(s), passive components and in-building antennas. Include the RF link budget for Uplink and Downlink Path. Provide all assumptions.
 - b. Overlay of the system design on building floor plan drawings

- c. Overlay on floor plan drawings of the predicted signal strength within the coverage area indicating, at a minimum, the -95 dBm downlink (base to mobile) signal strength for all coverage areas.
 - d. Building elevation and plan views depicting the location of any outdoor antennas associated with the proposed system. Include the antenna centerline height above building, orientation, mounting method, cabling, conduit route and the location of all external grounding connections.
 - e. BDA and Secondary Power Supply installation. Include plan and elevation views indicating equipment dimensions, mounting methods, enclosure type, cable and conduit routing, voltage required, power required, label locations and required clearance from other equipment. Identify each piece of equipment by brand, model number and equipment type.
 - f. Drawings and block diagrams are to be provided in AutoCAD format and accompanied by two (2) printed copies.
 - g. Shop drawings shall be 8.5 inch x 11 inch or greater, scaled or dimensioned, with dimensions or scale clearly noted. Floor plan drawings shall be 24 inch x 36 inch minimum with drawings scaled to legible size.
 - h. All components shall be consistently named or labeled for reference in other drawings, diagrams and tables.
- 3. Other Submissions
 - a. Specify antenna grounding and surge protection in accordance with NEC Article 810 and these specifications.
 - b. Specify the backup/secondary power source, and include calculations to ensure the backup power requirements as specified in this standard are met.
 - c. List of Individuals Responsible for the system design, planning and installation along with their qualifications and experience.
- B. Submittal Requirements Prior to the Start of System Installation
 - 1. Documentation confirming the latest information from the AHJ of the frequencies to be supported by the system.
 - 2. List of any approved system design changes required since the original bid and the reason for each change. This list includes any design changes required for approval by the AHJ.
 - 3. Updated Product Data, Shop Drawings and Diagrams reflecting any changes.
 - 4. Bill of Materials ("BOM")
 - 5. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be installed.
 - 6. System Installation Schedule as approved by the Owner, General Contractor and AHJ.
- C. Submittal Requirements at Project Close Out
 - 1. As-Built Drawings of all items required and in the formats listed in item A and B above.
 - 2. Test Reports
 - a. In-Building Coverage Test Results
 - b. Donor Antenna Isolation
 - c. Spectrum Analysis Report demonstrating only the intended frequencies are being carried on the system.

- d. Spectrum Analysis Report demonstrating no spurious oscillations, PIM or other intermodulation products are being produced that would affect other services or system performance.
 - e. Sweep test results of all coaxial cable runs
 - f. System Malfunction Alarm and its connection to the fire alarm panel.
 3. Record of system operating parameters including:
 - a. Signal levels received at the donor antenna
 - b. Signal levels at the input and output of the BDA
 - c. BDA Gain Settings
 4. Operation and Maintenance Data: Submit hardware and software manuals for all products including all features and operating parameters.
 5. Warranty Documents:
 - a. Submit for all manufactured components utilized in the system
 - b. Submit Manufacturer's Extended Warranty
 - c. Submit Contractor's System Warranty
 6. Submit the agenda for the training class along with copies of handouts to be utilized in the class.
 7. Compile the items listed in this section into a single Operations and Maintenance Manual to be provided in electronic format. Include drawings and block diagrams in Adobe Acrobat (.pdf) and in AutoCAD format. Include a section containing a copy of the latest maintenance, testing and reporting requirements of the AHJ.

1.08 QUALITY ASSURANCE

- A. Minimum Qualifications of Personnel
 1. Engineering and Design:
 - a. A valid Professional Engineering Certification and Certification of in-building system training issued by the manufacturer of the equipment being installed or
 - b. Approval issued by the AHJ
 - c. Include GROU requirement as stated by the latest IFC code.
 2. Installer Qualifications:
 - a. Minimum five years of experience installing systems of similar scope and complexity
 - b. Certified by the manufacturer of the BDA equipment to be installed
- B. All equipment shall be UL listed and labeled, and in accordance with applicable NEMA and ANSI Standards.
- C. All parts of racks and enclosures shall be welded or assembled with paint piercing ground washers, grounding strip and bonding jumper.

1.09 WARRANTY

The contractor shall warrant system performance as specified in this section for one year starting on the date of final system acceptance.

1.10 MAINTENANCE AND ANNUAL TESTING

- A. The contractor shall provide the first full year of maintenance for the system. The term of this maintenance period begins on the date of final system acceptance.
- B. Maintenance shall include
 - 1. 24-hour by 7-day emergency response within two hours after notification
 - 2. Annual testing
- C. Annual Tests
 - 1. BDA Operating Parameters:
 - a. Record signal and power levels
 - b. Review self-diagnostics and other items as recommended by the manufacturer
 - c. Note any parameter changes from previous tests, investigate causes
 - 2. Backup/Secondary Power Supply
 - a. Record voltage and charging of batteries before testing under load
 - b. Test batteries under full load for at least one hour or until the integrity of the batteries can be determined.
 - 3. Test system malfunction alarm and its connection to the fire alarm panel
 - 4. Maintain documentation on-site with a backup copy off-site.

PART 2 PRODUCTS

1.02 MANUFACTURERS

Subject to compliance with the requirements of this Section, manufacturers of the products that may be utilized in the system include, but are not limited to, the following:

- 1. CommScope/Andrew
- 2. Cobham
- 3. PCTEL
- 4. Times Microwave
- 5. RFS – Radio Frequency Systems
- 6. Microlab/FXR
- 7. Bird Technologies
- 8. EMR Corp.
- 9. Galtronics
- 10. ADRF
- 11. Notifier

1.03 SYSTEM COMPONENTS

- A. Donor Antennas
 - 1. Electrical:
 - a. Frequency band: covering the frequencies specified by the AHJ.
 - b. VSWR $\leq$ 1.5:1
 - c. Gain: $\geq$ 10.0 dBi
 - d. Maximum Input Power: 100 watts
 - e. Polarization: Vertical

- f. Front-to-back ratio: ≥ 15 dB
 - g. Vertical Beamwidth: ≤ 30 degrees
 - h. Horizontal Beamwidth: ≤ 60 degrees
 - i. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - b. Mounting: Mast on a non-penetrating mount utilizing concrete block ballast
 - c. Grounding/Bonding: Pursuant to NFPA 70 NEC Article 810 requirements
 - 3. Environmental:
 - a. Temperature: -40°C to $+60^{\circ}\text{C}$
 - b. Lightning Protection: Direct Ground
 - c. Maximum Rated Wind Velocity: 125 mph
 - 4. Antenna Cable:
 - a. All exposed cable shall have a UV stable black jacket for protection from sunlight
 - b. Cable feed to the BDA shall be $\frac{1}{2}$ " copper corrugated outer conductor foam dielectric coax.
 - c. Weatherproofing: exposed connectors protected from the effects of weather
 - d. Rigid conduit between the Donor location and BDA location shall be provided and installed by the contractor.
- B. Omni-Directional In-Building Coverage Antennas
 - a. Frequency band: 698-900 MHz
 - b. VSWR $\leq 1.8:1$
 - c. Gain: ≥ 1.0 dBi
 - d. Maximum Input Power: 25 watts
 - e. Polarization: Vertical
 - f. Vertical Beamwidth: ≥ 65 degrees
 - g. Horizontal Beamwidth: 360 degrees
 - h. PIM: < -150 dBc
 - i. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - b. Mounting: ceiling mount or securely mounted above ceiling
 - 3. Environmental:
 - a. Temperature: -20°C to $+70^{\circ}\text{C}$
 - b. Plenum rated
- C. Directional Coverage Antennas
 - 1. Electrical
 - a. Frequency band: 698-900 MHz

- b. $VSWR \leq 1.8:1$
 - c. Gain: ≥ 1.0 dBi
 - d. Maximum Input Power: 25 watts
 - e. Polarization: Vertical
 - f. Vertical Beamwidth: ≥ 65 degrees
 - g. Horizontal Beamwidth: 90 degrees - 180 degrees nominal
 - h. PIM: < -150 dBc
 - i. Impedance: 50Ω
 - 2. Mechanical:
 - a. Connector: 50Ω type N Female
 - b. Mounting: ceiling or wall mount
 - 3. Environmental:
 - a. Temperature: -20°C to $+70^{\circ}\text{C}$
 - b. Plenum rated
- D. Radiating Cable
 - 1. Material:
 - a. Nominal size: $\frac{1}{2}''$ or $\frac{7}{8}''$
 - b. Outer conductor: Corrugated copper
 - c. Slot Design: milled, two rows
 - d. Jacket Material: Non-halogenated, fire retardant polyolefin
 - e. Dielectric Material: Foam PE
 - f. Inner Conductor Material: Copper wire, copper tube or Copper-clad aluminum wire
 - g. Mounting: Minimum clearance of $2''$ from walls or other structure, secured at intervals and with hardware pursuant to manufacturer's specifications
 - 2. Electrical
 - a. Frequency Range: 30 – 2650 MHz
 - b. Impedance: $50\Omega \pm 1$
 - 3. Environmental:
 - 4. Temperature: -20°C to $+80^{\circ}\text{C}$
- E. Foam Dielectric Cable
 - 1. Material:
 - a. Nominal size: $\frac{1}{2}''$ or $\frac{7}{8}''$
 - b. Outer conductor: Corrugated copper
 - c. Dielectric Material: Foam PE
 - d. Inner Conductor Material: Copper wire, copper tube or Copper-clad aluminum wire
 - 2. Electrical

- a. Frequency Range: 30 – 2650 MHz
 - b. Impedance: $50\Omega \pm 1$
 3. Environmental:
 4. Temperature: -20°C to +80°C
- F. Splitters, Combiners, Couplers, Taps, Coax Jumpers and Connectors:
 1. Electrical
 - a. Frequency Range: 698 – 2700 MHz
 - b. VSWR $\leq 1.3:1$
 - c. Maximum Input Power: ≥ 50 watts
 - d. PIM: < -150 dBc
 - e. Impedance: 50Ω
 2. Mechanical:
 - a. Connector: 50Ω type N Female
 3. Environmental:
 - a. Temperature: -20°C to +70°C
- G. BDA: Bi-Directional Amplifiers utilized on the system must meet the following requirements:
 1. Electrical
 - a. Frequency agility: The unit shall have the capability to change operating frequencies within the 700 – 800 MHz Public Safety Band as may be required due to licensing changes of the AHJ or actions of the FCC.
 - b. Alarming Functions: The BDA shall be linked to the building's fire alarm panel and configured to signal an alarm in the event of a failure with the BDA or donor antenna system.
 - c. The BDA shall have received FCC Certification prior to installation.
 - d. The system must be compatible with both analog and digital transmissions.
 - e. Automatic gain and level controls shall be integrated into the BDA with a minimum dynamic range of 60 dB, less any gain reduction setting.
 2. Mechanical
 - a. All BDA components shall be housed in a single, NEMA4 cabinet. The cabinet must be waterproof and capable of dissipating all heat without the use of ventilation.
 - b. The BDA cabinet shall be painted fire engine red and display the following labeling in bright yellow letters: "RADIO REPEATER" unless alternate labeling is specified by the AHJ.
 - c. The name and telephone number of the vendor responsible for system maintenance also must be marked on the cabinet.
 - d. If the BDA is not located in the same room as the fire alarm panel, a sign shall be placed at the fire alarm panel with the name and telephone number of the local

Fire Department indicating that they shall be notified of any failures that extend past two hours.

- e. The cabinet shall be securely locked to prevent unauthorized access.

3. Environmental

- a. The BDA, as installed in the approved NEMA4 cabinet, shall be designed for operating in temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C).

H. Power Supplies: At least two (2) independent and reliable power supplies shall be provided, one primary and one secondary.

- 1. Primary Power: The primary power source shall be supplied from a dedicated 20 Ampere branch circuit. The presence of primary power shall be monitored by the BDA monitoring system and provide notification upon loss of primary power.
- 2. Secondary Power: The secondary power source shall be capable of operating the in-building radio system for at least 24 hours of 100% system operation. This system shall utilize a dedicated battery system or a self-starting generator with dedicated storage batteries.
 - a. The battery system shall automatically charge in the presence of the external/primary power input.
 - b. The secondary power system shall be engaged automatically upon loss of primary power.
 - c. The secondary power system shall be contained in one NEMA 4 enclosure.
 - d. An alarm shall be configured to signal failure of the battery charging system or if the battery charge falls below 70% of capacity.
- 3. Environmental
 - a. The secondary power system, as installed in the approved NEMA4 cabinet, shall be designed for operating in temperatures ranging from -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C).

PART 3 EXECUTION

3.1 INSTALLATION

- A. System Signal Wires, Power Conductors and Cables
 - 1. Wires and cables shall enter each equipment enclosure, cabinet or rack in such a manner that all doors or access panels can be opened and closed unobstructed by cables.
 - 2. Routing and Interconnection
 - a. Wires or cables routed between cabinets, racks, and other equipment shall be installed in an approved conduit or cable tray that is secured to the building structure.
 - 3. All cable shall be sweep tested for detection of any faults prior to and after installation. Sweep results shall be recorded for future reference.

4. Coaxial cable shall be carefully installed in strict compliance with the manufacturers' recommended procedures with special attention given to pulling tensions, bending radius and proper support.
5. Coaxial antenna cabling, except for radiating cable, shall be installed in its own metallic conduit.
6. All equipment, cable and components shall be installed and connected according to the OEM's specifications to insure correct installation and system performance.
7. Coordinate all roof penetrations with Owner and/or roofing contractor.

3.2 GROUNDING

- A. Ground and bond cable shields and equipment per Manufacturer's requirements and NFPA 70 NEC requirements.
- B. The Donor antenna mast shall be grounded per NFPA 70 NEC requirements. Grounding blocks and surge protection shall be provided for outside coaxial cabling.

3.3 ACCEPTANCE TESTING

- A. An initial set of system Commissioning Tests shall be performed for the Owner prior to final Acceptance Testing with the AHJ. The commissioning tests will include all tests outlined in Part 1.07 C.2., "Submittal Requirements at Project Closeout", "Test Reports".
- B. Tests shall be made using frequencies close to the frequencies used by the appropriate emergency services. If testing is done on the actual frequencies, then this testing must be coordinated with the local Department unit. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the licensed department frequencies.
- C. Final Acceptance Test Procedures
Acceptance testing shall consist of the following tests or those tests as may be directed by the AHJ and local County emergency response.
 1. Coverage Testing: For testing system signal strength and quality, the testing shall be based on the delivered audio quality (DAQ) system. A DAQ level below 3.4 shall be considered a failed test for a given grid cell. See Part 1.04, DEFINITIONS for descriptions of each DAQ level.
 - a. Each floor of the building shall be divided into 20 grid divisions. Increase to 40 if there is a failure. Critical areas tested separately.
 - b. The tests will be conducted by using a calibrated portable two-way radio of the latest brand and model as currently in use by the local Department.
 - c. Small scale drawings (11 inch x 17 inch maximum) of the structure shall be provided by the Contractor for use and documentation of the test results. The plans shall show each floor divided into the grids as described above, and the results of any pre-testing. Each grid shall be labeled to indicate the DAQ result from the final acceptance testing.

- d. DAQ tests shall be made with the antenna held in a vertical position at 3 to 4 feet above the floor to simulate a typical portable radio worn on the belt or turnout coat pocket.
 - e. A test location shall be selected near the center of each grid square. Once the test location of a grid area is selected, prospecting for a better spot within the area is permitted only within three feet (3') in any direction of the selected test location.
 - f. The two-way radio will be utilized to transmit voice transmissions to verify communications to and from the outside area covered by the Department's radio system. For each grid location, the DAQ of the transmission shall be determined.
 - g. A maximum of two non-adjacent areas will be allowed to fail the DAQ test.
 - h. In the event that three or more of the grid test locations fail the test, the floor may be re-tested by creating a new grid consisting of 80 equal areas and test locations selected within each area. In testing the new grid, a maximum of four non-adjacent areas may fail the test. If the system fails the 80 area test, then the system must be revised to meet the coverage requirement.
2. Isolation and Spectrum Analysis Testing:
- a. Measurement of the isolation between the donor antenna(s) and the system antennas shall be performed utilizing a spectrum analyzer and appropriate signal generator.
 - b. A Spectrum Analysis Report demonstrating only the intended frequencies are being carried on the system.
 - c. Spectrum Analysis Report demonstrating no spurious oscillations or intermodulation products are being produced that would affect other services or system performance.
3. Other tests as requested by the AHJ.

END OF SECTION

SECTION 28 1300 - ACCESS CONTROL SOFTWARE AND DATABASE MANAGEMENT

Part 1 General

1.1 Section Includes

- A. Provide a scalable, open architecture access control system for security management, including engineering, supply, installation, and activation.

1.2 Related Sections

- A. Section 260500 – Common Work Results for Electrical, for interface and coordination with building electrical systems and distribution.
- B. Section 280513 – Conductors and Cables for Electronic Safety and Security, for cabling between system servers, panels, and remote devices.
- C. Section 280528 – Pathways for Electronic Safety and Security, for conduit and raceway requirements.

1.3 References

- A. Reference Standards: Systems specified in this section must meet or exceed the following requirements:
 - 1. Federal Communications Commission (FCC)
 - a. FCC Part 15 – Radio Frequency Device
 - b. FCC Part 68 – Connection of Terminal Equipment to the Telephone Network
 - 2. Underwriters Laboratories (UL):
 - a. UL294 – Access Control Systems Units
 - 3. Electronic Industries Alliance (EIA):
 - a. RS232C – Interface between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange
 - b. RS485 – Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multi-Point Systems
 - 4. Federal Information Processing Standards (FIPS):
 - a. Advanced Encryption Standard (AES) (FIPS 197)
 - b. * FIPS 201-2: Open Options DNA Fusion FIPS in conjunction with an E2-SSP-

D2-FIPS and other listed components will provide an access control solution that is fully FIPS 201-2 compliant.

**The Open Options system will be submitted for GSA compliance testing which will commence on 1-13-2016.*

c. Personal Identity Verification (PIV) of Federal Employees and Contractors

5. Homeland Security Presidential Directive 12 (HSPD-12)

1.4 Access Control and Security Management System Description

- A. The Access Control and Security Management System (ACSMS) shall function as an electronic physical access and situational control system and shall integrate the alarm monitoring, Video Management System (VMS), ID badging, and database management into a single executable application. The ACSMS shall function as the primary means of controlling all access and situational control needs. A scalable, open architecture and network ready solution shall allow for an assured access and alarm monitoring solution.

1.5 Submittals

- A. Manufacturer's Product Data: Submit the manufacturer's data sheets indicating systems and components proposed for use.
- B. Shop Drawings: Submit complete shop drawings indicating system components, wiring diagrams and load calculations.
- C. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electronic version of record drawings for the Security Management System not later than Substantial Completion of the project.
- D. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, customized to the Security Management System installed. Include system and operator manuals.
- E. Maintenance Service Agreement: Submit a sample copy of the manufacturer's maintenance service agreement, including cost and services for a two-year period for Owner's review.

1.6 Quality Assurance

- A. Manufacturers
 - 1. A minimum of ten years' experience in manufacturing and design of access control systems using the Authentic Mercury Security hardware platform.

2. Recognized as a Mercury Security Platinum Elite Partner

B. Suppliers

1. Authorized Open Options dealers.
2. Office must be within 100-mile radius of the district office.

C. Fabricators

D. Installers

1. Minimum of 1 technician that has successfully completed Open Options' certification training course (within the last 24 months) will be present at the project site to supervise installation and test system during commissioning.

1.7 Delivery, Storage, and Handling

- A. Deliver materials in original packaging. Store and handle in accordance with the manufacturer's requirements.

1.8 Warranty

- A. Provide Manufacturer's warranty covering [1] year from date of shipment for replacement or repair of defective equipment.

1.9 Definitions

- A. Access Card: A coded employee card, usually the size of a credit card, recognizable to the access control system and read by a reader to allow access. It can be used for photo identification of the cardholder and for other data collection purposes. Card technologies include magnetic strips, wiegand-effect, proximity (active/passive), barium ferrite, smart/intelligent cards, and NFC enable applications on mobile devices.
- B. Access Control System: An interconnected set of controllers, managing the entrance and exit of people through secure areas.
- C. Access Level: The door or combination of doors and/or barriers an individual is authorized to pass through.
- D. Anti-Pass back (Anti-Tailgating): This feature protects against more than one person using the same card or number. It defines each system card reader and card ID number as IN, OUT or other. Once a card is granted access to an IN reader, it must be presented to an OUT reader before another IN reader access is granted. Cards will continue to have access to all authorized OTHER readers.
- E. Alarm: A signal that indicates a problem.

- F. Alarm input: A device that is monitored by the access control panel. An alarm signal will be generated if the device is activated.
- G. Badge: Badge is a template or a design for creating a card. WIN-PAK includes a full-featured badge layout utility for designing, creating, and printing badges. Badge design includes magnetic stripe encoding, bar coding, signatures, and so on.
- H. Bar Code: A method of encoding information using lines and blank spaces of varying size and thickness to represent alphanumeric characters.
- I. Biometrics: A general term for the verification of individuals using unique biological characteristics (i.e. fingerprints, hand geometry, voice analysis, the retinal pattern in the eye).
- J. Card and Card Holder: A card is an identity proof of a person and a card holder is a person who holds the card. Multiple cards can be assigned to a single card holder to provide different access.
- K. Controller: A microprocessor-based circuit board that manages access to a secure area. The controller receives information that it uses to determine through which doors and at what times cardholders are granted access to secure areas. Based on that information, the controller can lock/unlock doors, sound alarms, and communicate status to a host computer.
- L. Card Reader: A device that retrieves information stored on an access card and transmits that information to a controller.
- M. Digital Video Recorder (DVR): A security system device that records the video from the surveillance cameras (IP and Analog) on a hard disk.
- N. Door: A generic term for a securable entry way. In many access control applications a "door" may actually be a gate, turnstile, elevator door, or similar device.
- O. Duress: Forcing a person to provide access to a secure area against that person's wishes.
- P. Input: An electronic sensor on a controller that detects a change of state in a device outside the controller.
- Q. Keypad: An alphanumeric grid which allows a user to enter an identification code. A flat device which has buttons that may be pressed in a sequence to send data to a controller, and which differs from a typewriter-like computer board.

- R. Output Relay: A device that changes its state upon receiving a signal from a controller. Typically, the state change prompts an action outside of the controller such as activating or inactivating a device. The auxiliary relays found in access control panels or NODES that control external devices.
- S. Shunt Time: The length of time a door open alarm is suppressed (shunted) after a valid card access or free egress request. This time should be just enough to allow a card user to open a door or gate, pass through, and then close it.
- T. Time Schedules: Schedules that allow cards to function or not function depending on the time of day. This is used to limit access to the facility. The schedule may include not only time but which days of the week a card is valid.
- U. Video Management System (VMS): An enterprise-class video management and storage solution.

Part 2 Products

2.1 Manufacturer

- A. Lenel OnGuard Access Control System.
- B. Genetec
- C. Open Options

2.2 Access Control and Security Management System Components

The ACSMS shall consist of three components: Database Server, Application Server, and User Interface. These components shall run on a single computer, virtual or physical, or on multiple computers allowing scalability in the configured architecture.

1. Database Server
2. Application Server
3. User Interface

In addition to the above three components, the ACSMS offers the following components that can be added to the system in order to provide enhanced functionality.

1. Open DX – Personnel data exchange tool used for provisioning personnel/cardholder information and access level assignment within the DNA Fusion ACSMS there by creating a logical link to the authoritative data source. The authoritative data source shall be one or more ActiveX Data Objects (ADO) compliant connections. Some examples of ADO compliant connections are Microsoft Active Directory, PeopleSoft, SQL Server database, CSV file, etc.
2. Flex API – A robust Application Programmer’s Interface to be used for the integration of 3rd party systems in order to expand the overall ACSMS. These systems can include, but are not limited to, visitor management systems, video managements systems, identity management systems, intrusion detection systems, and physical security integration modules (PSIM).

2.3 Access Control and Security Management System Operational Requirements

- A. The ACSMS shall be a highly scalable, robust access control and security management system developed using the latest in development technology. The ACSMS shall provide a singular interface capable of controlling multiple, geographically independent sites and provide alarm monitoring, video management integration, ID badging, personnel and cardholder management, and situational control of all connected devices.
- B. The ACSMS must fully support the Authentic Mercury Security Corporation controllers and sub-controllers.
- C. The ACSMS must support credential readers that communicate via wiegand, RS-485, or clock and data communications formats.
- D. The ACSMS must support the Open Supervised Device Protocol (OSDP).
- E. A sufficient number of controllers and sub-controllers will be provided to monitor all credential reader, monitor point, and relay point locations shown on plan.

1. Capacities

- a. Maximum intelligent controllers per application server: 256
 - i. Intelligent controllers can be geographically independent
 - ii. Must support IP and/or RS-485 communication methods.
- b. Maximum sub-controllers per controller: 32
 - i. This number varies per model of controller.
 - ii. Some controller models may have a smaller number for maximum sub-controllers.

- c. Maximum doors per controller: 64
 - i. This number varies per model of controller.
 - ii. Some controller models may have a smaller number for maximum doors
- d. Maximum pin digits: 15
- e. Maximum card formats: Unlimited
- f. Maximum Time Schedules per intelligent controller: 255
- g. Maximum holidays per intelligent controller: 255
- h. Maximum number of personnel records: Unlimited
- i. Maximum number of operators: Unlimited
- j. Maximum number of client connections: Unlimited

F. The ACSMS shall be capable of the following features:

1. Multi-User/Network Capabilities: The ACSMS shall support multiple operator workstations via local area network/wide area network (LAN/WAN). The communications between the workstations and the server computer shall utilize the TCP/IP standard over industry standard IEEE 802.3 (Ethernet). The communications between the server and workstations shall be supervised and shall provide the ability to generate alarm messages when the server is unable to communicate with a workstation.
2. Operating Environment: The ACSMS shall be a 3-tier client/server, ODBC compliant application based on Microsoft tools and standards. The ACSMS application shall operate in the following environments: Microsoft Windows® Server 2008 R2 SP1, Microsoft Windows® 7 SP1 (64-bit), Windows Server 2012 R2, and Windows 8.1.
3. Multi-level Password Protection: The ACSMS application shall provide multi-level password protection, with user-defined operator name/password combinations. Name/password log-on shall restrict operators to selected areas of the program. The application shall allow the assignment of operator levels to define the system components that each operator has access to view, operate, change, or delete.
4. Strong Password Enforcement: The ACSMS application shall have an option to enforce strong passwords and by setting minimum character lengths and complexity requirements.

5. Graphical User Interface: The ACSMS shall be fully compliant with Microsoft Graphical User Interface (GUI) standards, with the look and feel of the software being that of a standard Windows application, including hardware tree-based system configuration.
6. Concurrent Licensing: The ACSMS shall support concurrent client workstation licensing. The ACSMS application shall be installed on any number of client workstations, and shall provide the ability for any of the client workstations to connect to the application server as long as the maximum number of concurrent connections purchased has not been exceeded.
7. Access Control Software Suite: The ACSMS shall be a scalable application such that there is no requirement for separate tiers or editions of software. The same code set used for smaller, more localized installations, shall be the same code set used for enterprise system deployments.
8. Relational Database Management System: The ACSMS shall support industry standard relational database management systems (RDMS). This shall include the following: Microsoft SQL Server 2012 Express/Enterprise Edition, Microsoft SQL Server 2008 R2 Express/Enterprise Edition, and Microsoft SQL Server 2014 Express/Enterprise Edition.
9. System Partitioning/Filtering: The ACSMS shall provide the option to restrict access to data based on login and profile.
10. Encryption: The ACSMS shall provide multiple levels of data encryption.
 - a. True 128-bit AES data encryption between the host and intelligent controllers. The encryption shall ensure data integrity that is compliant with the requirements of FIPS-197 and SCIF environments. Master keys shall be downloaded to the intelligent controller, which shall then be authenticated through the Access Control and Security Management System based on a successful match.
 - b. Transparent database encryption, including log files and backups.
 - c. SQL secure connections via SSL.
11. Industry Standard Panel Communication: The ACSMS shall communicate with the access control intelligent controllers via LAN/WAN connections utilizing industry standard communication protocols.
12. Supervised Alarm Points: The ACSMS shall provide both supervised and non-supervised alarm point monitoring with the ability to specify custom values of resistance. On recognition of an alarm, the ACSMS shall be capable of switching and displaying the video

- from the camera connected to the video management system that is associated with the alarm point.
13. Multiple Account Support: The ACSMS shall allow support for multiple accounts allowing separate access to the personnel database, badge layout, operator access, and reporting. Physical hardware may be filtered by profile level into “sites”. “Sites” may be assigned to one or more operator profiles. The system shall allow control of common areas between operator profiles. Access levels and time schedules shall be global to allow for easy administration and filtering. The global access levels and time schedules shall be capable of being used by one or more operator profiles.
 14. Video Management System Support: The ACSMS shall integrate with the major brands of video management systems (VMS).
 15. Camera Support: The ACSMS shall support, via integrated VMS platforms, pan, tilt, zoom, and touring features.
 16. Display Live Video: The ACSMS shall support an option to view live video from a camera connected to an integrated VMS. The cameras from the integrated VMS shall be able to be associated with any hardware device programmed in the ACSMS and opened automatically on any system event or operator-initiated command sequence.
 17. Global/Anti-Passback: The ACSMS shall support multiple modes of anti-passback, by which cardholders must follow a specified sequence of card reads in the configured areas.
 18. Alarm Events: The ACSMS shall include a feature where alarm events with defined priorities shall be able to pop-up automatically in an Alarm event window for operator attention. The pop-up shall display the following information: description of the event, time, date, point description, if a card event the card number, type of event and cardholder name. An event counter shall also display the number of times the event was reported to the Alarm event monitor prior to Acknowledgement or Clearing the event. Event instructions shall be made available by double clicking on the event. The Alarm shall also display an icon to indicate that a camera is associated to the device. The Alarm event window shall allow the operator to initiate a physical response to the event as well as a written response. Responses shall include but not be limited to: acknowledge, clear, open a pre-programmed floor plan, activate, de-activate, pulse, time pulse, add comment, retrieve archived video, and bring up live video, disarm, or arm.
 19. Global Device Control: The ACSMS shall allow manual control of one or more selected inputs, outputs, and doors. Global device control shall include pulse, timed pulse, and energize/de-energize or return to normal options for output points and arm/disarm or

- return to normal options for input points. For global control of doors, the ACSMS shall include Disabled, Unlocked, Locked, Facility Code Only, Card Only, PIN Only, Card and PIN, Override Mode, and Cancel Override Mode.
20. Global Edit: The ACSMS shall support, by way of a multi-select function, a method to globally edit input points, outpoint points, doors, readers, personnel and cards.
21. Levels of System Operation: The ACSMS shall include a feature to define the levels of system operation for each individual operator using passwords and profiles. System operation for individual operators shall include, but not be limited to, restricted time periods for login, inactivity notifications, and lockout for failed logon attempts. Operator actions range from no view or control rights to basic monitoring including the ability to block the viewing of card and or personal identification numbers, to full control of the system including programming.
22. Distributed Processing: All the control components of the ACSMS shall utilize "Distributed-Processing" design. The distributed processing shall include the ability to download operating parameters to any field panel, thus allowing the field panel to provide full operating functions independent of the ACSMS application server.
- G. The ACSMS shall have the major functional capabilities (considered essential for the system described in this specification) categorized as follows:
1. General Application Requirements
- a. All transactions and audits shall be logged by date and time to the database.
 - b. The end-user shall have the ability to make any system configuration changes such as, but not limited to door open time, door contact shunt time, point and door names, when and where a cardholder is authorized, and the ability to add or modify personnel records at any time and without assistance from the manufacturer or system installer.
 - c. Shall support Global Anti-pass back, feature allowing cardholders to enter/exit any such defined card reader area on any intelligent control panel provided they follow the required in/out flow.
 - d. Anti-pass back modes shall include: hard (no forgiveness), soft (allows access but generates an alarm event) and timed for all readers on the intelligent controller, on specified reader or card for a definable period of time up to 1092 minutes.

- e. Shall support a Duress PIN feature that is configurable in operation by which the cardholder either adds a specified digit to their unique PIN or appends a specified digit to their unique PIN.
- f. Shall support Two Card Control on any door, by which two different credentials with the proper access must be presented at the same door within a 5 second window of time.
- g. Shall support a Photo Recall option with four separate, configurable windows that displays the photo(s) associated with the personnel records as the credentials are used. The Photo Recall windows shall be configurable to show the credential reads from all doors, or only specific doors. In addition, the Photo Recall window shall be configurable as to what system data will be displayed for each transaction.
- h. Shall support the scheduling of any system or custom system reports.
- i. Shall support Auto-Email function, by which any event or point in the system can be configured to send an email using replacement parameters. The replacement parameters shall be used to query data from the database for insertion into the body, subject line, or address field of the email.
- j. All updates and changes to the programming in the intelligent controllers shall take place real-time and will not require manual downloads to propagate system changes.
- k. Shall have an available Application Program Interface (API) built on current development technologies that allows the integration of third-party programs or systems.
- l. Shall be an intuitive Graphical User Interface (GUI) that implements a multi-document layout. An operator will not be required to close or switch views to another part of the application in order to edit or view any aspect of the system. The GUI must be fully customizable allowing for an infinite number of operator views to be created and assigned. The GUI must support drag and drop functions within the multi-document interface.
- m. Shall support global I/O functions, by which any point in programmed in the system can be configured to control any other point on the system regardless of which intelligent controllers they reside on.

- n. All necessary system drivers shall run as Windows services and as such do not require the Operating System to be logged in on the application server.
- o. Shall have support for thick client, web client and mobile client applications that provide system management functions.
- p. Shall support a Situation Level Manager that provides five different states that can be initiated by clicking on a single, color coded button. The Situation Levels shall be configurable on the following objects: Doors, Time Schedules, Input Points, Output/Relay Points, and Credentials.
- q. Shall provide intuitive Info-Ready™ reporting by which an operator must only right click on an object to run a Trace History Report, Has Access To, Who Has Access, Who Does Not Have Access, Last Used, and Non-Use.
- r. The GUI shall be developed in such a manner that any place that a personnel record or hardware device is shown that an operator can right click on it and open the properties or execute control functions.
- s. Shall support a method of controlling any device connected to the system in order to effectively change the state of a single point or group of points where supported by the hardware.
- t. Shall support Direct Commands, which allow the creation of a single button to control a single or all devices simultaneously by clicking one button, based on operator privileges.
- u. Shall support the ability to password protect the Direct Commands to require additional authentication when executing them.

2. Personnel and Cardholder Management

- a. Shall provide a personnel browser method of managing personnel data in a hierarchical tree. The personnel browser shall be sortable by in field of data stored in the personnel record.
- b. Shall have the ability to create custom personnel groups that personnel records can be assigned to whereby personnel records can be assigned to one or more personnel groups.

- c. Shall have the ability to assign default access levels to custom personnel groups that cardholders will inherit or disinherit as they are added or removed to or from custom personnel groups.
- d. Shall have the ability to assign one or more credentials to a single personnel record.
- e. Shall support a maximum of 128 access levels per credential per intelligent controller.
- f. Shall support Precision Access Levels, by which an operator need not create an access level to assign access to a single door, but only click and drag said door into the access level assignment window of the credential and associate a time schedule with it.
- g. Shall support a Vacation Start function on credentials to allow the temporary disabling of cards for a specified number of days.
- h. Shall support a Temporary Upgrade of Access Levels by which an operator can temporarily assign an access level with start and stop dates.
- i. Shall support an activation and deactivation date and time of a credential down to the minute within a day.
- j. Shall support the capture of personnel photos and signatures to be used for ID badge printing.
- k. Shall support the ability for any personnel or credential field to be retrieved and printed on an ID badge.
- l. Shall support the ability for any or all credentials activate or deactivate based on a system-controlled Situation Level.
- m. Shall support Info-Ready™ reports on personnel groups providing the following information: Last Used and Non-Use.
- n. Shall support the ability to assign/re-assign credentials to personnel records by way of a drag and drop convention.

3. Time Schedules and Holidays

- a. Shall support up to 255 individual time schedules per time schedule set.
- b. Shall support up to 255 individual time schedule sets that are then assignable to intelligent controllers.
- c. Shall support up to 12 different start and stop intervals for each day, including holidays.
- d. Shall support time schedule templates to quickly build common time schedules.
- e. Shall support a copy feature to copy time schedules between time schedule sets.
- f. Time schedules shall be assignable to any or all access levels or precision access levels.
- g. Shall support the ability to manually control any or all-time schedules programmed in the system by providing the following commands: Temporary Off, Temporary On, Override Off, Override On, and Resume Normal State.
- h. Shall support the ability for any or all-time schedules to be manually controlled by the changing of the Situation Level Manager.
- i. Shall support up to 255 holiday sets that are then assignable to intelligent controllers.
- j. Shall support creating a holiday to span up to 365 days.
- k. Shall support up to eight different holiday types.

4. Access Levels

- a. Shall support an unlimited number of access levels.
- b. Access levels shall be capable of being global or intelligent controller based.
- c. Shall support the option to assign activation and deactivation dates/times to access levels.
- d. Shall support three types of escort requirements for access levels: Not an Escort, Is an Escort, and Requires an Escort.

- e. Shall support a default time schedule to be assigned to the access level or separate time schedules to individual doors within the access level.
- f. Shall support eight different access level categories that can then be assigned to operator profiles granting rights to assign the category of access level or not.
- g. Shall support an Info-Ready™ report named Assigned To that provides a list of all credentials the access level is assigned to with the ability to remove the access level from cardholders directly from the result set window.
- h. Shall support a click and drag method of assigning access levels to a single credential, personnel record, or group of personnel records.

5. Hardware

- a. Shall support a browser based, hierarchical tree structure that displays the programmed hardware with current states and provides command and control capabilities based on operator privileges.
- b. The tree structure shall be developed in such a way that it is intuitive for the operator to navigate.
- c. The tree structure shall provide, based on operator privileges, the ability to group edit and control similar devices.
- d. The tree structure shall have an option to display a tooltip upon hovering over a specific device to obtain detailed status information.

6. Integrated ID Badging

- a. Shall have an integrated photo capture and ID badging module.
- b. The integrated ID badging module shall support an unlimited number of badge templates.
- c. The badging station shall include a badge designer to create badge templates.
- d. The badge designer shall allow any data field associated with a personnel record to be printed or otherwise used on the credential.

- e. The integrated ID badging module shall support a dedicated, high end photo badging camera from Valcam (Model# 9000-628).
- f. The integrated ID badging module shall support, through the use of a third-party TWAIN Driver, the ability to use any TWAIN compliant USB camera.
- g. The badge designer shall provide scripting capabilities to create a robust and streamlined template process by which the layout of a single template can be edited based on data retrieved from the personnel record.
- h. The integrated ID badging module shall support a cropping mechanism in order to resize photos and select the printable area of the picture.
- i. The integrated ID badging module shall support any credential printer that has a Windows print driver
- j. The integrated ID badging module shall offer, depending upon the printer selected, the ability to create a template that will read the encoded card number from the credential as it passes through the printer during the printing process and then associate it with the personnel record automatically, thereby removing the need for the operator to manually enter the credential number. This feature will require a reader/encoder be installed inside the printer prior to setup.
- k. The integrated ID badging module shall provide a print preview function that allows the operator to verify the credential format prior to actually printing it.
- l. The integrated ID badging module shall support the capturing of signatures during the credentialing process.

7. Integrated Graphics Maps

- a. Shall provide, with no additional licensing fees required, an integrated and robust graphical map module allowing for the importation of floor plans and other .JPG or .BMP files for use in plotting hardware and other connected devices programmed in the system onto the graphic layouts.
- b. Shall support the ability to assign a graphic map as a homepage of any point in the system, thereby linking that device to that map and allowing the system to automatically load the graphic upon an alarm condition from any point that is plotted on it.

- c. Shall support any command and control or reporting functions available in the Hardware Browser for any point that is plotted on a graphic map.
- d. Shall support the hyperlinking of graphic maps to one another, thereby creating a “drill down” effect.
- e. Shall support the ability to plot any camera that is integrated to the core application onto a graphics map and display the live video in a tooltip window upon the operator hovering over the icon, or displaying of live video in a video container window upon left clicking the camera icon.
- f. Shall support the real-time status updating of points that are plotted on a graphics map by configurable colors, shapes, or icons.
- g. Shall support the ability to plot the same device on a single graphic map multiple times to get varying states of status reported simultaneously.
- h. Shall support the ability to create buttons on the graphic maps which can then be linked to Direct Commands.

8. Mobile Applications

- a. Must have auxiliary mobile application supported on Android and iOS devices
- b. Mobile applications will be native applications and not remote/mobile browser solutions.
- c. Mobile applications will be available for download from the respective application markets, and will not require side loading of any kind.
- d. Mobile applications will utilize profiles established in the DNA Fusion system to control what the operator has the ability to do via the mobile application.
- e. Mobile application will support the following features:
 - i. Secure login using SSL
 - ii. Alarm viewing/acknowledgement
 - iii. Door status and control
 - iv. Personnel control, to include adding access levels and taking photos using the devices camera
 - v. Direct Command execution allowing for site or system lockdowns.
 - vi. Trace History reporting

- vii. Live camera viewing from supported/integrated Video Management Systems.

9. Integrated Video Management Systems

- a. Shall support the integration of Digital Video Recorders (DVR) and Network Video Recorders (NVR) from the following manufacturers:
 - i. Milestone
 - 1. Corporate
 - 2. Enterprise
 - 3. Professional
 - ii. ONSSI
 - 1. Occularis
 - iii. ExacQ Vision
 - iv. Aimetis
 - v. Pelco DS
 - vi. Video Insight
 - vii. Bosch
 - viii. Salient Systems
 - ix. Panasonic
 - x. 3XLogic
 - xi. Avigilon
- b. Shall support the ability to associate cameras from DVR/NVR to devices in DNA Fusion.
- c. Shall support, at minimum, the ability to launch live and recorded video based on a right click command in the DNA Fusion software, or automatically based on a pre-programmed event based action.
- d. Shall support the ability to initiate presets or PTZ controls

2.4 ACSMS Computer Requirements

1. DNA Fusion Application Server Requirements

- a. DNA Fusion Application Server controlling 50 doors or less and 10 clients or less
 - i. Processor (Intel Core i7 or equivalent) or greater
 - ii. 4 GB RAM or greater

- iii. 500GB HDD or greater
- iv. 10/100 NIC or greater
- v. Windows 7 Enterprise, Windows 8/8.1 Enterprise, Windows 10 Enterprise, Windows Server 2008 R2, Windows Server 2012 (*Operating systems must be Professional/Enterprise versions and not Home/Personal editions.)

b. DNA Fusion Application Server controlling 50 doors or more and 10 clients or more

- i. Processor (Intel Core i7 or equivalent) or greater
- ii. 8 GB RAM or greater
- iii. 500GB HDD or greater
- iv. 10/100 NIC or greater
- v. Windows Server 2008 R2, Windows Server 2012

c. Open Options fully supports virtualized environments provided the specifications meet the minimums listed above.

2. DNA Fusion Client Workstation Requirements

a. DNA Fusion Standard and Photo ID Workstations

- i. Processor (Intel Core i7 or equivalent) or greater
- ii. 4 GB RAM or greater
- iii. 500GB HDD or greater
- iv. 10/100 NIC or greater
- v. Windows 7 Enterprise, Windows 8/8.1 Enterprise, Windows 10 Enterprise (*Operating systems must be Professional/Enterprise versions and not Home/Personal editions.)

2.5 Access Control Hardware Requirements

1. The access control hardware will be a distributed intelligence, open architecture platform capable of scalability.
2. The access control hardware shall be offered in two form factors: as board only product or as enclosed product.
3. The enclosed product shall be offered as a factory, pre-wired unit and must be a UL recognized assembly.

4. The enclosed products must be offered as a 1U rack mountable intelligent controller or as a plenum rated poly carbonate enclosure.
5. The access control hardware will be in use and deployed by a minimum of 10 access control manufacturers.
6. The access control hardware shall work in a hierarchical structure, by which an intelligent controller is deployed and control downstream Reader Interface Modules (RIM) or Input/Output Modules (I/OM).
7. The access control hardware shall support the following communication protocols:
 - a. TCP/IP
 - b. RS485
8. The access control hardware shall be manufactured by Mercury Security Products in Long Beach, CA
9. The access control hardware shall consist of the following part numbers:
 - a. Intelligent Controllers
 - i. SSP-D2
 - ii. SSP-EP
 - iii. DController
 - iv. NController
 - v. M5-IC
 - b. Reader Interface Modules
 - i. RSC-1
 - ii. RSC-2
 - iii. NSC-100
 - iv. RSC-DT
 - v. M5-2RP
 - vi. M5-2SRP
 - vii. M5-8RP
 - c. Input/Output Modules
 - i. ISC-16
 - ii. OSC-16
 - iii. M5-20IN
 - iv. M5-16DO

v. M5-16DOR

d. RS485 Multiplexers

- i. CI-8
- ii. OptoHub
- iii. M5-COM

Part 3 Execution

3.1 EXAMINATION

1. Examine site conditions to determine site conditions are acceptable without qualifications. Notify Owner in writing if deficiencies are found. Starting work is evidence that site conditions are acceptable.

3.2 INSTALLATION

1. Integrated Security Management System, including but not limited to access control, alarm monitoring, CCTV, and ID badging system shall be installed in accordance with the manufacturer's installation instructions.
2. Supervise installation to appraise ongoing progress of other trades and contracts, make allowances for all ongoing work, and coordinate the requirements of the installation of the Security Management System.

3.3 FIELD TESTING AND CERTIFICATION

1. Testing: The access control, alarm monitoring, CCTV, and ID badging system shall be tested in accordance with the following:
 - a. Conduct a complete inspection and test of all installed access control and security monitoring equipment. This includes testing and verifying connection to equipment of other divisions such as life safety and elevators.
 - b. Provide staff to test all devices and all operational features of the Security Management System for witness by the Owner's representative and authorities having jurisdiction as applicable.
 - c. Correct deficiencies until satisfactory results are obtained.
 - d. Submit written copies of test results.

END OF SECTION 28 1300

SECTION 28 1500 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Card readers, credential cards, and keypads
 - 2. Biometric identity-verification equipment
 - 3. Cables
 - 4. Transformers
- B. Related Requirements:
 - 1. Section 281300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.

- C. Product Schedules.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
 - 2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 - 1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.
 - 1. Card access equipment MUST be provided by an approved UNCW Certified Lenel VAR and the VAR must be approved by UNCW Physical Security and Access. Installation and wiring of all access control equipment MUST be performed by Lenel Certified technicians. Physical Security and Access MUST approve any equipment changes.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 3R enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type 3R enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 OPERATION

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70, "National Electrical Code."
- C. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07.

2.3 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Card Readers:
 1. Manufacturers:

- a. RK-40 HID iClass Keypad Reader with terminal connection – Part Number: 921INTNTEK0004L *this reader is the standard to be used for all installations unless a change has been approved by the UNCW Physical Security and Access Manager.
 - b. RK-40 HID iClass Keypad Reader with pigtail connection – Part Number 921INTNNEK0004L
 - c. R-40 HID iClass Reader with terminal connection – Part Number 920NTNTEK0003V
 - d. R-40 HID iClass Reader with pigtail connection – Part Number 920NTNNEK0003V
 - e. R-10 HID iClass Mullion Mount Reader with terminal connection – Part Number 900NTNTEK0004F
 - f. R-10 HID iClass Mullion Mount Reader with pigtail connection – Part Number 900NTNNEK0004F
2. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
3. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.
4. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
 - a. Indoors, controlled environment.
 - b. Indoors, uncontrolled environment.
 - c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
5. Wiegand Swipe Reader: Set up for 33-bit data cards. Comply with SIA AC-01.
6. Touch-Plate and Proximity Readers:
 - a. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction, and shall receive and decode a unique identification code number transmitted from the credential card.
 - b. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
 - c. The card reader shall read proximity cards in a range from direct contact to at least 6 inches (150 mm) from the reader.

B. Keypads:

1. Entry-control keypads shall use a unique combination of alphanumeric and other symbols as an Identifier.

2. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII-code ordinal sequence
 3. Communication protocol shall be compatible with the local processor.
 4. Keypad Display:
 - a. Keypads shall include a digital visual indicator and shall provide visible and audible status indications and user prompts.
 - 1) Display shall indicate power on or off and whether user passage requests have been accepted or rejected.
 - b. Design of the keypad display or keypad enclosure shall limit viewing angles of the keypad as follows:
 - 1) Maximum Horizontal Viewing Angle: Plus, or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
 - 2) Maximum Vertical Viewing Angle: Plus, or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
 5. Keypad Response Time:
 - a. The keypad shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 ms or less from the time the last alphanumeric symbol is entered until a response signal is generated.
 6. Keypad Power:
 - a. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
 7. Keypad Mounting Method:
 - a. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
 8. Keypad Duress Codes:
 - a. Keypads shall provide a means for users to indicate a duress situation by entering a special code.
- C. Keypad and Wiegand-Swipe-Reader Combination: Designed to require an entry on the keypad before presenting the credential card.
1. Keypad: Allow the entry of four numeric digits that are associated with a specific credential. Keypads shall contain an integral alphanumeric/special symbol keyboard

with symbols arranged in ascending ASCII-code ordinal sequence. Keypad display or enclosure shall limit viewing angles of the keypad as follows:

- a. Maximum Horizontal Viewing Angle: Plus, or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
 - b. Maximum Vertical Viewing Angle: Plus, or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
2. Wiegand Swipe Reader: Set up for 33-bit data cards to generate a unique card identification code. Comply with SIA AC-01.
 3. The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
 4. Communication Protocol: Compatible with local processor.

D. Credential Cards:

1. Manufacturers:
 - a. HID One Card
2. Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
3. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
4. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
5. Card Construction:
 - a. Core and laminate or monolithic construction.
 - b. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
 - c. Furnish equipment for on-site assembly and lamination of credential cards.

2.4 PUSH-BUTTON SWITCHES

- A. Push-Button Switches: Momentary-contact back-lighted push buttons with stainless-steel switch enclosures.
- B. Electrical Ratings:

1. Minimum continuous current rating of 10 A at 120-V ac or 5 A at 240-V ac.
 2. Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.
- C. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
- D. Enclosures shall additionally be suitable for installation in the following locations:
1. Indoors, controlled environment.
 2. Indoors, uncontrolled environment.
 3. Outdoors.
- E. Power: Push-button switches shall be powered from their associated controller, using dc control.

2.5 CABLES

- A. General Cable Requirements: Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems" and as recommended by system manufacturer for integration requirement.
- B. PVC-Jacketed, TIA 232-F.
1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Polypropylene insulation.
 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 4. PVC jacket.
 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with UL 1581.
- C. Plenum-Rated TIA 232-F Cables:
1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. PE insulation.
 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 4. Fluorinated ethylene propylene jacket.
 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.
- D. PVC-Jacketed, TIA 485-A Cables:
1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. PVC insulation.
 3. Unshielded.

4. PVC jacket.
 5. NFPA 70 Type: Type CM.
 6. Flame Resistance: Comply with UL 1581.
- E. Plenum-Rated TIA 485-A Cables:
1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Fluorinated ethylene propylene insulation.
 3. Unshielded.
 4. Fluorinated ethylene propylene jacket.
 5. NFPA 70 Type: Type CMP
 6. Flame Resistance: NFPA 262, Flame Test.
- F. Multiconductor, PVC, Reader and Wiegand Keypad Cables:
1. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CMG.
 3. Flame Resistance: UL 1581 vertical tray.
 4. For TIA 232-F applications.
- G. Paired, PVC, Reader and Wiegand Keypad Cables:
1. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CM.
 3. Flame Resistance: UL 1581 vertical tray.
- H. Paired, PVC, Reader and Wiegand Keypad Cables:
1. Three pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CM.
 3. Flame Resistance: UL 1581 vertical tray.
- I. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:
1. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG,

- stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 - 2. NFPA 70, Type CMP.
 - 3. Flame Resistance: NFPA 262 flame test.
- J. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:
- 1. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 - 2. NFPA 70, Type CMP.
 - 3. Flame Resistance: NFPA 262 flame test.
- K. LAN Cabling:
- 1. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."
- 2.6 TRANSFORMERS
- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.
- 2.7 POWER SUPPLIES
- A. Power supplies for all electric locksets shall be Von Duprin model PS914-4RL.
- 2.8 DOOR LOCKSETS
- A. Shall be either:
 - 1. Best electric mortise lock with request to exit and internal deadbolt with indicator for internal doors.
 - 2. Von Duprin panic device with low current request to exit switch.
 - 3. Best electric mortise lock with request to exit and storeroom function for instances which require a mortise lock for external doors.
 - B. All locksets shall be approved by a UNCW Locksmith and UNCW Physical Security and Access.
 - C. Interior doors shall conform to a mortise lockset. Exterior doors shall conform to a panic device lockset. Electric strikes and Magnetic locks are NOT acceptable. All other configurations require approval from UNCW Locksmith and UNCW Physical Security and Access.

- D. Interior doors specified with card access and furnished with an electrified mortise lock shall contain a temperature control module built into the lockset or shall have a temperature control module provided with the lockset.

2.9 DOOR POSITION SWITCHES

- A. Manufacturers:
 - 1. GE Security 1078C series
 - 2. Approved equivalent
- B. Preferred choice of door monitoring shall be a magnetic $\frac{3}{4}$ " diameter door position switch.
- C. On double doors where each leaf has a DPS, the devices shall be wired in series. Both sensors shall report alarms to the system as a single alarm point.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.
- E. Power Supplies must be mounted in a secure space and shall NOT be installed above doors or ceilings.

3.2 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Install cables and wiring according to requirements in Section 270513 "Conductors and Cables for Communications Systems."

- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.
- F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- G. Install end-of-line resistors at the field device location and not at the controller or panel location.
- H. Splicing of wires and conductors shall not be permitted.
- I. Spare conductors in cables shall not be eliminated. Cut the spare conductors to the same length as the conductors in use and wrap them around the cable jacket for future use.

3.3 CABLE APPLICATION

- A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. Install door control cabling in a minimum of 1" EMT conduit originating from control board to junction box mounted in accessible ceiling space above door.
- D. TIA 232-F Cabling: Install at a maximum distance of 50 ft. between terminations.
- E. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. between terminations.
- F. Communications Panel:
 - 1. A network data drop is required at the main Lenel communications panel (UNCW will designate a network port). Additional Lenel door access panels in other areas of the

building require a 2 pair 22 awg stranded cable or a CAT6 cable to the main Lenel Communications panel. The maximum distance shall be 1000 feet unless a Lenel 8000 multiplexer is installed increasing the distance to 4000 feet.

G. Lock Power:

1. EL98/99NL - No. 12 AWG – 180 feet
2. QEL97/99NL - No. 12 AWG – 300 feet
3. Mortise/Strike - No. 16 AWG – 300 feet

H. Door Position and Request to Exit:

1. In single door application: A (1) pair 22-gauge stranded cable is used for RX connections. This cable shall be run to the center door hinge area of the door using $\frac{3}{4}$ " flex conduit from the junction box and shall be terminated with an electric pass through hinge. A (1) pair 22-gauge stranded cable for the DPS shall be run in $\frac{3}{4}$ inch flex conduit from the junction box to top of door frame, no farther than one foot from latch side of door.
2. In double door application: The right-hand door from the outside or reader side shall require all specifications of single door wiring. The additional door shall require (1) pair 22-gauge stranded cable for the DPS and shall be run in $\frac{3}{4}$ " flex conduit from the junction box to top of door frame, no farther than one foot from latch side of door, and a second (1) pair 22-gauge stranded cable will be required for RX connections in a $\frac{3}{4}$ inch flex conduit from the junction box to the center hinge of the door.

I. Card Readers and Keypads:

1. Install number of conductor pairs recommended by manufacturer for the functions specified.
2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft., and install No. 20 AWG wire if maximum distance is 500 ft..
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
5. Pulled to single gang box at the card reader location: A (3) pair 22-gauge shielded stranded gauge wire shall be used for the door reader and pulled through a $\frac{3}{4}$ " flex conduit from the junction box to a single gang junction box in the area designated for mounting of the card reader.

J. Handicap Door Controller Cable:

1. Pulled to Handicap Door Controller: If a handicap door opener is required, a Cat 6 cable or 22/6 stranded shielded wire shall be pulled from the access control board to the control board of the handicap opener. This shall pass through the junction box and be in a $\frac{3}{4}$ " flex conduit to the handicap door opener control board. All terminations of this

wire shall be performed by the installation contractor. Termination and installation of opener and paddles is the responsibility of the GC.

- K. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. between terminations.
- L. All cabling shall be installed in a manner that will protect the cable from damage during installation, facilitate cable management and identification and provide a neat and groomed appearance.
- M. The horizontal cables shall be bundled in the Access Control Security room ladder tray, using Velcro cable ties.
- N. Plastic ty-wraps are not allowed in the Access Control Security room.

3.4 GROUNDING

- A. Comply with Section 270526 "Grounding and Bonding for Communications Systems."
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.
 - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.5 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.
- B. All panels and power supplies shall be labeled so that service technicians can easily identify the location of readers, lock power, inputs and outputs.

3.6 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
 - 2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
 - 3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
- C. Devices and circuits will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
 - 1. Complete installation and startup check according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
 - 2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

END OF SECTION 28 1500

SECTION 28 3111 - ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. If smoke detectors are installed within 10 feet of a restroom door opening or within 10 feet from vanity/sink area, the smoke detectors shall be programmed as "verified" smoke detectors.
- C. Isolation relays (relays indirectly controlled by fire alarm system components) or 8 amp rated fire alarm system component relays shall be used whenever 120VAC (or greater) is switched by relay contracts to control auxiliary functions.
- D. Line voltage (120VAC transient) suppressors providing surge protection to the fire alarm control panel shall have dry contacts for remote monitoring of transient suppressor integrity. These contacts shall be monitored by the fire alarm control panel to indicate a trouble condition when the operating ability of the suppressor is lost.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fire-alarm control unit.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Notification appliances.
 - 6. Magnetic door holders.
 - 7. Remote annunciator.
 - 8. Addressable interface device.
 - 9. System printer.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

- C. Control Unit: Fire Alarm control unit

1.4 SYSTEM DESCRIPTION

- A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 INSPECTIONS

- A. The contractor shall contact the State Inspector to schedule a final inspection of the fire alarm system.

1.6 SUBMITTALS

- A. General Submittal Requirements:
 - 1. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified fire-alarm technician, Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
 - 2. Include voltage drop calculations for notification appliance circuits.
 - 3. Include battery-size calculations.
 - 4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
 - 6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculations for voice evacuation system, and single-line connection diagram.
 - 7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

- D. Qualification Data: For qualified Installer, certifications.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For fire-alarm systems 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. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 2. Provide signed copies of "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter. Submit copies to the Owner, NC State Construction Office and the Architect.
 - 3. A copy of Fire Alarm System Matrix indicating the control unit response to each initiating device signal.
 - 4. A complete copy of the North Carolina State Construction office checklist, "Fire Alarm System Checklist." Copies shall be distributed to the Owner, NC State Construction Office, and the Architect.
 - 5. Provide an electronic copy of the control unit system program via compact disk to the Owner.
 - 6. A complete copy of the "System Status and Programming Report" after programming and testing is complete for the whole system. The report shall include the settings for all alarm initiating devices and current sensitivity of analog addressable smoke detectors.
 - 7. A record copy of site-specific software.
 - 8. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
 - a. Frequency of testing of installed components.
 - b. Frequency of inspection of installed components.
 - c. Requirements and recommendations related to results of maintenance.
 - d. Manufacturer's user training manuals.
 - 9. Manufacturer's required maintenance related to system warranty requirements.
 - 10. Abbreviated operating instructions for mounting at the control unit.
 - 11. Copy of NFPA 25.
- G. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

H. Close Out Documents:

1. To be attached to the as-built drawing set, provide a full-size drawing that includes the following:
 - a. Diagram illustrating the loop numbers, devices addresses, and terminal numbers to which devices connect to the control equipment
 - b. Amplifier load calculations for voice evacuation system.
 - c. Battery Sizing
 - d. EOL voltage drop
2. Provide two bound copies of the following to the Owner:
 - a. Manufacturer's maintenance requirements.
 - b. Technical literature of all control equipment, power supplies, isolation modules, alarm initiating devices, notification devices, relays, etc.
 - c. Training summary by factory authorized service representative.
3. Program Software Backup: On magnetic media or compact disk, complete with data files.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by authorized personnel trained and certified by the manufacturer and a minimum NICET Level III certification for technicians installing and connecting the system. All personnel performing the work shall have had training within the last 36 months.
- C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 PROJECT CONDITIONS

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

1.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Completion, provide software support for two years.
- C. Upgrade Service:
 - 1. Update software to latest version at Project completion.
 - 2. Install and program software upgrades that become available within two years from date of Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 3. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.
 - 4. Include software upgrades including licensing and operating systems as required for corrections or operating issues at no charge to the owner for the life of the system.

1.10 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: Two of each type installed in the system.
 - 2. Manual Fire Alarm Boxes: Quantity equal to 6 percent of amount installed.
 - 3. Monitor Modules (Addressable Interface): Quantity equal to 6 percent of amount installed.
 - 4. Isolation Modules/Bases (Addressable Interface): Quantity equal to 6 percent of amount installed.
 - 5. Addressable Control Relays: Quantity equal to 6 percent of amount installed.
 - 6. Smoke Detectors, Fire Detectors: Quantity equal to 6 percent of amount of each type installed.
 - 7. Speakers with Strobes: Quantity equal to 6 percent of amount of each type installed.

8. Sounder Bases: Quantity equal to 6 percent of amount of each type installed.
9. Lamps for Strobe Units: Quantity equal to 6 percent of amount installed.
10. Keys and Tools: One extra set for access to locked and tamper-proofed components.
11. Programming Equipment/Tools for system devices: Four (4) minimum required for proprietary equipment.

1.11 WARRANTY

- A. Warranty: At no additional charge to the Owner, the manufacturer shall agree to fully repair and/or replace the fire alarm system equipment and components that fail because of defect in materials or workmanship within the warranty period. The warranty shall include all labor, material, testing, and recertification after repairs are complete.
- B. Warranty Period: A minimum of one year from the date the system is accepted by the owner.
- C. The system is considered accepted when the final inspection by the State Construction Office and recommendation of the Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
 1. NOTIFIER; a Honeywell company.
 2. Edwards System Technology, Inc.
 3. Silent Knight.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 1. Manual stations.
 2. Heat detectors.
 3. Smoke detectors.
 4. Duct smoke detectors.
 5. Automatic sprinkler system water flow.
 6. Heat detectors in elevator shaft and pit.
 7. Fire extinguishing system operation.
 8. Dry system pressure switch.

- B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances.
 2. Identify alarm at fire-alarm control unit and remote annunciators.
 3. Release fire and smoke doors held open by magnetic door holders.
 4. Activate voice/alarm communication system.
 5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 7. Activate computer room suppression system.
 8. Recall elevators to primary or alternate recall floors.
 9. Activate emergency shutoffs for gas and fuel supplies.
 10. Record events in the system memory.
 11. Record events by the system printer.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
 2. Elevator shunt-trip supervision.
 3. Smoke dampers in closed position.
 4. Manual/Automatic activation of the hood suppression system.
 5. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
 6. Loss of communication with any panel on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of primary power at fire-alarm control unit.
 4. Ground or a single break in fire-alarm control unit internal circuits.
 5. Abnormal ac voltage at fire-alarm control unit.
 6. Break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at fire-alarm control unit or annunciator.
 9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
 10. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.
- E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- B. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
 - a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Shall be listed to control pre-action and clean agent release systems.
 - d. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment:
 2. Addressable initiation devices that communicate device identity and status.
 - a. System shall automatically balance for smoke detector sensitivity changes due to ambient conditions and dust build-up within detectors. Set sensitivities prior to acceptance of the system.
 - b. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
 - c. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
 3. Addressable control circuits for operation of mechanical equipment.
 - a. Provide 1" conduit to building automation panel (mechanical digital controls) and controlling circuits to integrate fan/air handling shutdown per matrix and specifications.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, 2 line(s) of 80 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Sound general alarm if the alarm is verified.
4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

E. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits (SLC): NFPA 72.
 - a. Initiating Device Circuits: Class A, Style D.
 - b. Notification Appliance Circuits: Class B, Style Y.
 - c. Signaling Line Circuits: Class A, Style 6, (taps are not allowed)
 - 1) Install a maximum of 20 addressable devices between isolation modules for each SLC.
 - 2) Provide and locate an isolation module at the midpoint where fewer than 20 addressable devices are on a SLC.
 - d. Provide a minimum of 20% spare capacity and addresses for future use on each SLC.
2. Serial Interfaces: Two RS-232 ports for printers.
3. Voltage drop shall not exceed 14% at EOL after 24 hours of standby plus 15 minutes of full building alarm.

F. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall.
 - a. Elevator lobby detectors except the lobby detector on the designated floor.
 - b. Smoke detector in elevator machine room.
 - c. Smoke detectors in elevator hoistway.
2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
 - a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

- H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out the final adjusted values on system printer.
- I. Fire/Smoke Damper Reset Button: Provide a single button integral at the control unit to open/close smoke dampers for the entire building.
- J. Key operated and supervised "ERV Shutdown Defeat" switch: Provide an integral keyed switch at the control unit to perform as follows: When the key switch is turned to "on" position, it shall disable the automatic shutdown of the ERV units during an alarm condition. The switch shall cause a system "trouble" indication when placed in the off-normal (Shutdown Defeated) position.
- K. Transmission to Remote Alarm Receiving Station:
- L. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
 - 1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
 - a. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.
 - e. Normal audio amplifier power shall be a minimum of 120% of the system design load, per channel. For the purpose of the calculation, use the amplifier's continuous two-tone output rating and the designed power settings of each individual speaker.
 - f. At least one backup amplifier shall be provide for each channel, equal in power to the largest primary amplifier. Failure of any amplifier shall automatically result in defective unit being switched off-line and replaced with the backup.
 - 2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
 - M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
 - N. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and supervisory signals shall be powered by 24-V dc source.
 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
 - O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
 1. Batteries: Sealed lead calcium.
 2. Provide battery capacity to sustain a minimum of 24 hours of standby plus 15 minutes of full (whole building) alarm mode.
 - P. The system shall be equipped with surge protective devices to prevent damage or nuisance alarms from voltage transients, lightning strikes, or stray currents. The devices are to be provided by the fire alarm equipment supplier. Line voltage (120VAC transient) suppressors providing surge protection to the fire alarm control panel shall have dry contacts for remote monitoring of transient suppressor integrity. These contacts shall be monitored by the fire alarm control panel to indicate a trouble condition when the operating ability of the suppressor is lost.
 - Q. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.
- 2.4 MANUAL FIRE-ALARM BOXES
- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
 - b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
 - c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (180 in the boiler room) or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
- B. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

- C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens.
 - 1. Rated Light Output:
 - a. 15, 30, 75, 110, 177 cd as indicated on the plans.
 - b. 15/30/75/110 cd, selectable in the field.
 - 2. Mounting: Wall mounted unless otherwise indicated.
 - 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 - 4. Flashing shall be in a temporal pattern, synchronized with other units.
 - 5. Strobe Leads: Factory connected to screw terminals.
 - 6. Mounting Faceplate: Factory finished, white.
- D. Voice/Tone Notification Appliances:
 - 1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
 - 2. High-Range Units: Rated 2 to 15 W.
 - 3. Low-Range Units: Rated 1 to 2 W.
 - 4. Mounting: Flush.
 - 5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
 - 1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
 - 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 - 3. Rating: 24-V ac or dc.
- B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 - 1. Mounting: Flush cabinet, NEMA 250, Type 1.

- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

- A. Monitor Module: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal switching the following conditions:
 - 1. 24 VAC transient suppressed loads: 2A
 - 2. 24 VAC inductive loads: 1A (such as fire/smoke dampers).
 - 3. 120 VAC transient suppressed loads: 0.5A (such as shunt mechanism at circuit breaker).

2.11 SYSTEM PRINTER

- A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system. Use non-thermal paper.

2.12 WIRING

- A. Addressable loop (signaling line) circuits shall be wired with type FPL/FPLR/FPLP fire alarm cable, AWG 18 minimum, low capacitance, stranded, twisted shielded copper pair. Cable shield drain wires are to be connected at each device on the loop to maintain continuity, taped to insulate from ground, and terminated at the FACP. Acceptable cables include Atlas 228-18-1-1STP, BSCC S1802s19 (same as EEC 7806LC), West Penn D975, D991 (AWG 16), D995 (AWG 14), or equal wire having capacitance of 30pf/ft. maximum between conductors. Belden 5320FJ acceptable if only FPL rating needed. The cable jacket color shall be red, with red (+) and black (-) conductor insulation.
 - 1. Unshielded cable, otherwise equal to the above, is permitted to be used if the manufacturer's installation manual requires, or states preference for, unshielded cable.
 - 2. In underground conduit, use Type TC or PLTC cable (PE insulated) to avoid problems from moisture.

2.13. DACT

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
 - 1. Cellular line – single main source. Provide Napco Starlink (SLD-CMDA-FIRE) fire alarm communicator and SLE-ANTEXT50 external antenna to match existing CMS cellular dial out service. Cellular dial out shall be backed up as part of battery backup as well as generator backed up where available. Provide a second cellular digital communicator, as noted above to serve as a back-up.

- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on the cellular line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal. Transmitter shall automatically report cellular service restoration to the central station. If service is lost, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address of the trouble-initiating device.
 - 4. Loss of ac supply.
 - 5. Loss of power.
 - 6. Low battery.
 - 7. Abnormal test signal.
 - 8. Communication bus failure.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Smoke- or Heat-Detector Spacing:
 - 1. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
 - 2. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
 - 3. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.
 - 4. If smoke detectors are installed within 10 feet of a restroom door opening or within 10 feet from vanity/sink area, the smoke detectors shall be programmed as "verified" smoke detectors.

- C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
- D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
- E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position. Provide remote status and alarm indicators for all duct detectors, install in the nearest corridor or public area and identify it with an engraved label affixed to the ceiling or wall.
- F. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- G. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.
- H. Annunciator: Install with top of panel not more than 60 inches above the finished floor.
- I. Fire alarm system wiring shall be installed in EMT where not within residential suites. Install EMT in all commercial and common areas.
- J. All conduits that penetrate outside walls from air-conditioned space must have internal sealing (duct-seal), to prevent condensation from infiltrating humid air
- K. All wiring shall be color coded. All the circuits in the system shall be wired with AWG 14, minimum, stranded copper, THHN/THWN conductor, installed in metallic conduits. Color Coded wires shall be in accordance with the following scheme, which shall be maintained throughout the system, without color change in any wire run:
 - 1. Initiating Circuits, General ----- Red (+)/White (-)
 - 2. Initiating Circuits, Smoke Only ----- Violet (+)/Gray (-)
 - 3. Signal Line Circuit cable ----- Red jacket with Red (+)/Black (-)
 - 4. Alarm Indicating Appliance Circuits ----- Blue (+)/Black (-)
 - 5. AHU Shutdown Circuits ----- Yellow (+)/Brown (-)
 - 6. Door Control Circuits ----- Orange
 - 7. Elevator Capture Circuits ----- Brown
- L. There shall be no splices in the system other than at device terminal blocks, or on terminal blocks in cabinets. "Wire nuts" and crimp splices will not be permitted. Permanent wire markers shall be used to identify all connections at the FACP and other control equipment, at power supplies, and in terminal cabinets. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type.
- M. Provide isolation relays (relays indirectly controlled by the fire alarm system) or 8 amp rated fire alarm system components) relays shall be used whenever 120VAc (or greater) is switched by relay contacts to control auxiliary functions.

- N. Separate walk test groups for all fire sprinkler devices shall be programmed into the fire alarm system.
- O. Duct Smoke Detectors shall be configured to report as Supervisory Alarms instead of Fire Alarms. They shall be configured to operate all necessary ancillary functions associated with smoke control such as air handler shutdown, damper activation, and smoke evacuation fans as required.

3.2 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Smoke dampers in air ducts of designated air-conditioning duct systems.
 - 2. Alarm-initiating connection to elevator recall system and components.
 - 3. Supervisory connections at valve supervisory switches.
 - 4. Supervisory connections at elevator shunt trip breaker.
 - 5. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
 - 6. Supervisory connections at fire-pump engine control panel.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Install permanently framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a dedicated ground wire from local telecomm ground bar to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 - b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

- G. Annual Test and Inspection: One year after date of Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

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

END OF SECTION 28 3111

SECTION 31 10 00 - SITE CLEARING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Removing existing vegetation.
 - 2. Clearing and grubbing.
 - 3. Stripping and stockpiling topsoil.
 - 4. Removing above- and below-grade site improvements.
 - 5. Disconnecting, capping or sealing, removing site utilities, and abandoning site utilities in place.
 - 6. Temporary erosion- and sedimentation-control measures.
- B. Related Sections:
 - 1. Division 01 Section "Execution"
 - 2. Division 01 Section "Construction Waste Management and Disposal"
 - 3. Division 31 Section "Erosion and Sedimentation Control"

1.3 DEFINITIONS

- A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.
- D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
- E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings defined by a circle concentric with each

tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated on plans.

- F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

- A. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

- A. Pre-installation Conference: Conduct conference at the Project site.

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify "North Carolina OneCall (811)" for area where Project is located before site clearing.
- C. Obtain UNCW "Dig Permit", keep permit current throughout construction, and keep University personnel current with planned construction activities and locations.
- D. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place and erosion control permit is obtained and posted at job-site.
- E. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."
 - 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on- site.

PART 3 EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Wrap a 1-inch blue vinyl tie tape flag around each tree trunk at 54 inches above the ground.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of NCDEQ.
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 EXISTING UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
 - 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
 - 1. Coordinate with Owner prior to shutting off any utilities.
 - 2. Arrange with utility companies to shut off indicated utilities.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Owner, and Engineer not less than 7 days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Engineer's written permission.
- E. Excavate for and remove underground utilities indicated to be removed.
- F. Verify horizontal and vertical location of existing underground utilities to remain in service on construction site. Notify Owner and Engineer immediately if a conflict with construction activities is discovered.

3.4 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
 3. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along the line of existing pavement and concrete to remain before removing adjacent existing pavement or concrete. Saw-cut faces vertically.

3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 10 00

SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation and City of Wilmington Standard Specifications and Details where applicable.

1.2 SUMMARY

- A. Section Includes:
 - 1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
 - 2. Excavating and backfilling for structures.
 - 3. Subbase course for concrete walks and pavements.
 - 4. Subbase course and base course for asphalt paving.
 - 5. Subsurface drainage backfill for walls and trenches.
 - 6. Excavating and backfilling trenches for utilities and pits for buried utility structures.
- B. Related Sections:
 - 1. Division 01 Section "Construction Progress Documentation" for recording pre-excavation and earth moving progress.
 - 2. Division 01 Section "Temporary Facilities and Controls" for temporary controls, utilities, and support facilities; also for temporary site fencing if not in another Section.
 - 3. Division 31 Section "Site Clearing" for site stripping, grubbing, stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
 - 4. Division 31 Section "Erosion and Sedimentation Control".
 - 5. Division 32 Section "Segmental Retaining Walls".
 - 6. Division 33 Section "Storm Utility Drainage Piping".

1.3 UNIT PRICES

- A. Work of this Section is affected by unit prices and quantity allowances for earth moving specified in Division 01 Section "Unit Prices and Allowances."

1.4 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 3. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Engineer or Owner's Testing Agency. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
 - 4. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
 - 5. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Engineer or Owner's Testing Agency. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Reinforced Soil Fill: Soil materials specifically designed and compacted for use with Segmental Retaining walls designed by others.

- J. Structural Fill: Soil free of trash, refuse, frozen material, or other deleterious materials, and contains less than 3% organics. Shall be free of rock or gravel larger than allowed for fill or backfill material as specified hereinafter or as shown on the drawings.
- K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- L. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
 - 1. Geosynthetics.
 - 2. Lime and/or cement utilized for soil/base modification.
 - 3. ABC stone
 - 4. Detector warning tapes.
- B. Material Test Reports: For each off-site soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 698.
- C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
- B. Pre-excavation Conference: Conduct conference at the Project Site prior to commencement of site grading.

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, parking lots, access drives, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Obtain a Dig Permit from UNCW and notify "North Carolina OneCall (811)" for area where Project is located before beginning earth moving operations.
- C. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 31 Sections "Site Clearing" and "Erosion and Sedimentation Control" are in place.
- D. Do not commence earth moving operations until a NCDEQ Erosion Control Plan Letter of Approval are obtained and posted at the project site.
- E. Do not commence earth moving operations until plant-protection measures specified in Division 01 Section "Temporary Tree and Plant Protection" are in place.
- F. The following practices are prohibited within protection zones:
1. Storage of construction materials, debris, or excavated material.
 2. Parking vehicles or equipment.
 3. Foot traffic.
 4. Erection of sheds or structures.
 5. Impoundment of water.
 6. Excavation or other digging unless otherwise indicated.
 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

- B. Satisfactory Soils: Unified Soil Classification System (USCS) Groups SM, SC, SW, and SP according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, greater than 3% organic material, and other deleterious matter.
 - 1. Compacted to not less than 95% of the Standard Proctor maximum below 12" and not less than 98% of the standard Proctor maximum for the last 12".
 - 2. Fill soils should possess a standard Proctor maximum dry density of at least 100 pounds per cubic foot (pcf) for the structural fill and at least 90 pounds per cubic foot (pcf) for the low permeability fill.
- C. Unsatisfactory (or Unsuitable) Soils: Soil Classification Groups OL and OH according to ASTM D 2487, or a combination of these groups.
 - 1. Fill materials shall not be classified as unsatisfactory if the fill materials' natural moistures are outside the required moisture range and otherwise meet the material requirements for satisfactory materials. The contractor shall dry these materials to the acceptable moisture range.
- D. Base Course: Aggregate meeting the ABC stone requirements specified in section 1005-3 and 1005-4 of the North Carolina Department of Transportation Standard Specifications for Roads and Structures, January 2012.
- E. Structural Fill: Same as Satisfactory Soils.
- F. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- G. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.
- H. Sand: ASTM C 33; fine aggregate.
- I. Low Permeability Fill: ASTM D 2487; CL, CH, and MH soil classification groups or a combination of these groups; free of debris, waste, frozen materials, vegetation, and other deleterious matter. Shall have a maximum dimension of 3 inches. Shall have a permeability of equal to or less than that value indicated on the design drawings when compacted to the degree indicated on the design drawings.
- J. Dam Embankment/Key Trench: Unified Soil Classification System (USCS) Groups ML and CL according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 6 inches in any dimension, roots, stumps, wood, debris, waste, frozen materials, and other deleterious matter.

1. All fill soils used in the Dam Embankment/Key Trench construction shall be compacted to at least 95% of the standard proctor maximum dry density (ASTM-698).
2. Fill Soils shall be compacted at a moisture content within -1 to +3 percent of its optimum moisture content

2.2 GEOTEXTILES

- A. Subsurface Drainage / Separation Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:
 1. Grab Tensile Strength: 205 lb; ASTM D 4632.
 2. Grab Tensile Elongation: 50%; ASTM D 4632.
 3. Trapezoidal Tear Strength: 80 lb; ASTM D 4533.
 4. CBR Puncture Strength: 500 lb; ASTM D 6241.
 5. Apparent Opening Size: No. 80 sieve, maximum; ASTM D 4751.
 6. Permittivity: 1.1 per second, minimum; ASTM D 4491.
 7. UV Stability: 70 percent after 500 hours' exposure; ASTM D 4355.
- B. Stabilization Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 1. Grab Tensile Strength: 247 lbf; ASTM D 4632.
 2. Sewn Seam Strength: 222 lbf; ASTM D 4632.
 3. Tear Strength: 90 lbf; ASTM D 4533.
 4. Puncture Strength: 90 lbf; ASTM D 4833.
 5. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
 6. Permittivity: 0.02 per second, minimum; ASTM D 4491.
 7. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.
- C. Detectable Tracer Wire: In accordance with NC General Statute 87-121 (g), the University requires a #12 solid bare copper wire is to be installed with gravity sewer mains and services, storm drainage systems, reuse mains and services, and any nonmetallic water service tubing. It is not required for DIP water mains or copper water services.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Follow Construction Sequence provided on Drawings.
- B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
- C. Protect and maintain erosion and sedimentation controls during earth moving operations.

- D. Remove from site, material encountered in grading operations that is unsatisfactory material or undesirable for backfilling, subgrade, or foundation purposes. Dispose of in manner satisfactory to Owner and local governing agencies. Backfill areas with layers of satisfactory material and compact as specified herein.
- E. Remove from site, material encountered in grading operations that is unsatisfactory material or undesirable for backfilling, subgrade, or foundation purposes. Dispose of in manner satisfactory to Owner and local governing agencies. Backfill areas with layers of satisfactory material and compact as specified herein.
- F. Prior to placing fill in low areas, such as previously existing creeks, or ponds, perform following procedures:
 - 1. Drain water out by gravity with ditch having flow line lower than lowest elevation in low area. If drainage cannot be performed by gravity ditch, use adequate pump to obtain the same results.
 - 2. After drainage of low area is complete, remove muck, mud, debris, and other unsatisfactory material by using acceptable equipment and methods that will keep natural soils underlying low area dry and undisturbed.
 - 3. All muck, mud, and other materials removed from low areas shall be dried on-site by spreading in thin layers for observation. Material shall be inspected and, if found to be satisfactory for use as fill material, shall be incorporated into lowest elevation of site filling operation, but not within 5'-0" of perimeter of paving or retaining wall subgrade. If, after observation, material is found to be unsatisfactory, it shall be removed from site.
- G. After topsoil stripping, notify Owner's Testing Agency. Proof-roll exposed subgrades to identify soft pockets and areas of excess yielding. Do not proof-roll wet or frozen subgrades.
 - 1. Completely proof-roll subgrade in one direction with a heavy vibratory smooth drum roller, having a weight of at least 10 tons, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner's Testing Agency, and replace with compacted backfill or fill as directed.
- H. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 EXPLOSIVES

- A. Explosives and/or blasting are expressly prohibited.

3.3 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include pavements, underground structures, utilities, obstructions, and other items indicated to be removed; together with soil, boulders, and rock. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or unsuitable soils to subgrade elevation.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials, replace with satisfactory materials.
- B. Unsatisfactory Soils: Volume of unsatisfactory soils and/or unsuitable debris actually removed below the subgrade/bearing elevation, measured in original position, and replaced with satisfactory subgrade/foundation material that meets the allowable design bearing pressure, compaction requirements, and construction documents for the site and structure. Unsatisfactory soils shall not be removed until approved and the volume is determined by measuring the excavation by the Owner's Testing Agency. Truck counts will not be accepted as a method to determine unsatisfactory soils removed. Changes in the Contract Sum or the Contract Time will be in accordance with Allowances and Unit Prices provisions for removal and replacement of unsuitable soils.

3.4 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
 - 1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
 - 2. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.6 SUBGRADE EVALUATION

- A. Notify Owner's Testing Agency when excavations have reached required subgrade.
- B. If Owner's Testing Agency determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below pavements in to identify soft pockets and areas of excess yielding. Do not proofroll wet or frozen subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner's Testing Agency, and replace with compacted backfill or fill as directed.
- D. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions, or unsuitable soils to subgrade elevation.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavations as directed by Engineer.

3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations.
 - 2. Place silt fence approximately 3-ft from edge of stockpile.
 - 3. Do not store within drip line of remaining trees.

3.9 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.

2. Surveying locations of underground utilities for Record Documents.
 3. Testing and inspecting underground utilities.
 4. Removing concrete formwork.
 5. Removing trash and debris.
 6. Removing temporary shoring and bracing, and sheeting.
 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.10 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil.
- D. Trenches under Roadways: After installing and testing piping or conduit less than 30 inches below surface of roadways, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."
- E. Backfill voids with satisfactory soil compacted in accordance with specifications provided herein while removing shoring and bracing.
- F. Place and compact initial backfill of subbase material and satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- G. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- H. All underground piping and utilities (both metallic and non-metallic), except lawn irrigation lines, shall have two stages of identification and/or warning by a combination of non-detectable and detectable warning tapes.
- I. Install warning tape (detectable warning tape) directly on top of the pipeline and permanently secured to the pipeline at 10' intervals.

- J. Install identification tape (non-detectable warning tape) approximately 18" to 30" above the service pipe, but a minimum of 10" and a maximum of 24" below finished grade.
- K. Install tracer wire to bottom of pipe taped at a maximum of 10' intervals. An insulated copper tracer wire or other approved conductor shall be installed along the length of the pipe to all nonmetallic piping, including irrigation lines, and metallic pipe with compression gasket fittings installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type "UF" (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.11 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers using satisfactory fill (or structural fill) to required elevations.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.12 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 3 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Fill materials shall not be classified as unsatisfactory if the fill materials' natural moistures are outside the required moisture range and otherwise meet the material requirements for satisfactory materials. The contractor shall dry these materials to the acceptable moisture range.
 - 3. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 3 percent and is too wet to compact to specified dry unit weight.

3.13 COMPACTION OF SOIL BACKFILLS AND FILLS

- B. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- C. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- D. Compact as follows:

Location	Percent of Maximum Laboratory Density
	ASTM D698
Subgrade and Fill below Structures and Pavement (top 12 inches)	98
Subgrade and Fill below Structures and Pavement (below top 12 inches)	95
Subgrade & Fill in All other Areas	90

3.14 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 - 2. Walks: Plus or minus 1 inch.
 - 3. Pavements: Plus or minus 1/2 inch.

3.15 BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place base course on subgrades approved by the Owner's Testing Agency free of mud, frost, snow, or ice.
- B. On prepared subgrade, place base course under pavements and walks as follows:
 - 1. Place base course material over subgrade under hot-mix asphalt pavement.
 - 2. Shape base course to required crown elevations and cross-slope grades.
 - 3. Place base course 10 inches or less in compacted thickness in a single layer.
 - 4. Place base course that exceeds 10 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 4 inches thick.

5. Compact base course at moisture content within +/- 2% of optimum moisture to required grades, lines, cross sections, and thickness to not less than 98 percent of maximum dry unit weight according to AASHTO T-180 as modified by NCDOT.
- C. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each base layer to not less than 98 percent of maximum dry unit weight according to AASHTO T-180 as modified by NCDOT.

3.16 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 2. Determine that fill material and maximum lift thickness comply with requirements.
 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
 4. Full-time observation and testing for retaining walls.
- B. Owner's Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to evaluate and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 1. Paved: At subgrade and at each compacted fill and backfill layer, at least one test for every 2500 sq. ft. or less of paved area, but in no case fewer than three tests.
 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.
- D. Maintain subgrades to receive base course stone within compaction and moisture requirements continuously until stone is placed.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Transport surplus satisfactory soil and topsoil to designated storage areas on Owner's property or remove from site and legally dispose as directed by Engineer. Stockpile or spread soil as directed by Engineer.
 - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

SECTION 31 23 17 – TRENCHING

PART 1 GENERAL

1.1 GENERAL NOTES

- A. Prior to beginning Work, Contractor to request a field inspection with the Owner and Engineer for inspection before project start and before project acceptance.
- B. Trenches for underground piping, where necessary shall be excavated to the required depth and bell holes shall be provided where necessary to insure uniform bearing. Trench excavation lines shall provide sufficient clearance for proper execution of underground work.
- C. Trenches shall be open cut from the surface. Irregularities at bottom of trench, or where excavation is below required depth shall be refilled to required grade with compacted soil, or flowable fill at direction of onsite geotechnical engineer.
- D. The Contractor shall be held responsible for the sufficiency of sheeting and bracing and for all damages to property or injury to persons resulting from improper quality, strength, placing and maintenance of trench shoring, sheeting or bracing.
- E. Existing utility lines to be retained that are shown on construction drawings or locations of which are made known to the Contractor prior to excavation operations, shall be protected from damage during excavation and backfilling, and if damaged shall be repaired by Contractor, at own expense.
- F. Existing utility lines found during excavations that were not shown on construction drawings or made known to Contractor prior to excavation shall be protected and remain uninterrupted until approval by Owner or Engineer to proceed.
- G. The Contractor shall be responsible for providing and maintaining a pedestrian and traffic control plan in accordance with University standards.
- H. All underground utilities encountered during the projects construction shall be located by a Professional Land Surveyor licensed in North Carolina.

1.2 DEFINITIONS

- A. Standard Specifications: When referenced in this section, shall mean North Carolina Department of Transportation Road and Bridge Specifications, January 2012. Parts of these Standard Specifications that are specifically referenced shall become part of this section as though stated herein in full. In case of a discrepancy between the requirements of the Standard Specifications and the requirements stated herein, the requirements herein shall prevail.

1.3 SUMMARY

A. Section Includes:

1. Excavating trenches for utilities from 5 feet outside any building to terminating connection.
2. Compacted fill from top of utility bedding to finished grade.
3. Backfilling and compaction.

B. Related sections:

1. Section 312000 – “Earth Moving”
2. Section 312919 – “Dewatering”
3. Section 312500 – “Erosion and Sedimentation Control”

1.4 SUBMITTALS

- A. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.
- B. Product Data: Geotextile fabric indicating fabric and construction.
- C. Materials Source: Name of imported fill materials suppliers.

1.5 QUALITY ASSURANCE

- A. Perform Work according to NCDOT and City of Wilmington standards.
- B. Prepare excavation protection plan under direct supervision of professional engineer experienced in design of this Work and licensed in State of North Carolina.

1.6 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.7 COORDINATION

- A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 PRODUCTS

2.1 FILL MATERIALS

- A. Subsoil Fill: Type as specified in Standard Specifications.

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- B. Structural Fill: Type as specified in Standard Specifications.
- C. Granular Fill: Type as specified in Standard Specifications.
- D. Concrete:
 - 1. Lean concrete.

2.2 ACCESSORIES

- A. Geotextile Fabric: Non-biodegradable, non-woven. Use NCDOT standard for fabric application and type by use.

PART 3 EXECUTION

3.1 LINES AND GRADES

- A. Lay pipes to lines and grades indicated.
 - 1. Engineer may make changes in lines, grades, and depths of utilities when changes are required for Project conditions.
- B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

- A. Call local utility line information service at 811 not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Obtain UNCW "Dig Permit".
- C. Identify required lines, levels, contours, and datum locations.
- D. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- E. Protect bench marks, existing structures, trees, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- F. Maintain and protect above and below grade utilities indicated to remain.
- G. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.3 TRENCHING

- A. Excavate subsoil required for utilities.

- B. Remove lumped subsoil, boulders, and rock over 6 inches.
- C. Perform excavation within 24 inches of existing utility service according to utility's requirements.
- D. Do not advance open trench more than 200 feet ahead of installed pipe.
- E. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with Work, dewater in accordance with Section 31 23 19.
- F. Excavate bottom of trenches to a maximum of 2 feet past outside diameter dimensions or outside of concrete cradle.
- G. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and pipe.
- H. When Project conditions permit, slope side walls of excavation starting 24 inches above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this Section.
- I. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by onsite Geotechnical Engineer until suitable material is encountered.
- J. Cut out soft areas of subgrade not capable of compaction in place. Backfill with flowable fill or geotechnical engineer approved fill and compact to density equal to or greater than requirements for subsequent backfill material.
- K. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.
- L. Correct areas over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Engineer.
- M. Remove excess subsoil not intended for reuse, from Site.
- N. Stockpile excavated material in area designated on Site according to Section 31 25 00.

3.4 SHEETING AND SHORING

- A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.
- B. Support trenches excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation or at direction of onsite geotechnical engineer.
- C. Design sheeting and shoring to be removed at completion of excavation Work.
- D. Repair damage caused by failure of sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

- E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 BACKFILLING

- A. Backfill trenches to contours and elevations with unfrozen fill materials.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.
- C. Place fill material in continuous layers and compact.
- D. Protect open trench to protect the public.

3.6 FIELD QUALITY CONTROL

- A. Test as required in Section 31200, "Field Quality Control".
- B. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.7 PROTECTION OF FINISHED WORK

- A. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION 31 23 17

SECTION 31 23 19 – DEWATERING

PART 1 GENERAL

1.1 GENERAL NOTES

- A. Excavations should be kept dry at all times by means of cofferdams, trenches, sumps, pumps or other equipment or arrangements required and approved.
- B. Prevent surface water from flowing into excavations, ponding on prepared subgrades and from flooding Project site and surroundings.
- C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation and/or subsurface seepage.
- D. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations or trenches. Establish and maintain temporary drainage ditches and other diversions outside excavation limits as required and approved by Owner or Engineer.
- E. Do not use excavations or trenches as temporary drainage ditches.

1.2 SUMMARY

- A. Section Includes:
 - 1. Construction site dewatering.
- B. Related sections:
 - 1. Section 312500 - "Erosion and Sedimentation Control"

1.3 DEFINITIONS

- A. Dewatering includes the following:
 - 1. Removing surface or ground water from within excavations or trenches.
 - 2. Disposing of removed water.
- B. Surface Water Control: Removal of surface water within open excavations.

1.4 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
 - 1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

1.5 QUALITY ASSURANCE

- A. Pre-installation Conference: Conduct conference at Project site.
 1. Review methods and procedures related to dewatering including, but not limited to, the following:
 - a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
 - b. Proposed site clearing and excavations.

1.6 PROJECT CONDITIONS

- A. Survey Work: Engage a qualified land surveyor to survey adjacent structures and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Engineer if changes in elevations occur or if any damage is evident in adjacent construction.

PART 2 PRODUCTS (*NOT USED*)

PART 3 EXECUTION

3.1 EXAMINATION

- A. Conduct additional borings and investigations to supplement subsurface investigations identified as required to complete dewatering system design.
- B. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
 1. Request underground utilities to be located and marked within and surrounding construction areas.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Monitor dewatering systems continuously.
- E. Promptly repair damages to adjacent facilities caused by dewatering.
- F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 31 25 00 during dewatering operations.

3.3 INSTALLATION

- A. Contractor shall furnish, install, operate, and maintain any pumping equipment, etc. needed for removal of water from various parts of the site at no additional cost to the Owner.
- B. Contractor shall coordinate with Geotechnical Engineer as needed.
- C. Work shall be in accordance with NCDOT standards.

3.4 FIELD QUALITY CONTROL

- A. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION 31 23 19

SECTION 31 23 24 - FLOWABLE FILL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flowable fill for:
 - a. Structure backfill.
 - b. Utility bedding.
 - c. Utility backfill.
 - d. Filling abandoned utilities.
 - e. Concrete Cradle.

1.2 DEFINITIONS

- A. Utility: Any buried pipe, duct, conduit, manhole, tank, or cable.
- B. Excavatable Flowable Fill: Lean cement concrete fill used where future excavation may be required such as fill for utility trenches, bridge abutments, and culverts.
- C. Non-excavatable Flowable Fill: Lean cement concrete fill used where future excavation is not anticipated such as fill below structure foundations and filling abandoned utilities.

1.3 SUBMITTALS

- A. Materials Source: Name of flowable fill materials suppliers.
- B. Mix Design:
1. Furnish flowable fill mix design for each specified strength. Furnish separate mix designs when admixtures are required for following:
 - a. Flowable fill Work during hot and cold weather.
 - b. Air entrained flowable fill Work.
 2. Identify design mix ingredients, proportions, properties, admixtures, and tests.
 3. Furnish test results to certify flowable fill mix design properties meet or exceed specified requirements.
- C. Delivery Tickets:
1. Furnish duplicate delivery tickets indicating actual materials delivered to Project Site.

1.4 QUALITY ASSURANCE

- A. Perform Work according to State of North Carolina Department of Transportation standards.

- B. Manufacturer: Company specializing in manufacturing products specified in this Section with three years' experience.

1. Product source approved by authority having jurisdiction.

1.5 ENVIRONMENTAL REQUIREMENTS

- A. Do not install flowable fill during inclement weather or when ambient temperature is less than 40 degrees F.

PART 2 PRODUCTS

2.1 FLOWABLE FILL

- A. Furnish materials according to State of North Carolina Department of Transportation standards.
- B. Flowable Fill: Excavatable type.
- C. Flowable Fill for Stormwater Control Measure Cradle: Non-Excavatable Type

2.2 MATERIALS

- A. Portland Cement: ASTM C150 Type I - Normal.
- B. Fine Aggregates: ASTM C33.
- C. Water: Clean and not detrimental to concrete.

2.3 ADMIXTURES

- A. Furnish materials according to State of North Carolina Department of Transportation standards.

2.4 MIXES

- A. Mix and deliver flowable fill according to ASTM C94/C94M, Option C.
- B. Flowable Fill Design Mix:

ITEM	EXCAVATABLE	NON-EXCAVATABLE
Cement Content	75 to 100 lb/cu yd	100 to 150 lb/cu yd
Fly Ash Content	None	150 to 600 pcf
Water Content	As specified	As specified
Air Entrainment	5-35 percent	5-15 percent

28-Day Compressive Strength	Maximum 100 psi	Minimum 125 psi
Unit Mass (Wet)	80 to 110 pcf	100 to 125 pcf
Temperature, Minimum at Point of Delivery	50 degrees F	50 degrees F

- C. Provide water content in design mix to produce self-leveling, flowable fill material at time of placement.
- D. Design mix air entrainment and unit mass are for laboratory design mix and source quality control only.

2.5 SOURCE QUALITY CONTROL

- A. Test and analyze properties of flowable fill design mix and certify results for following:
 - 1. Properties of hardened flowable fill design mix including:
 - a. Compressive strength at 1 day, 7 days, and 28 days. Report compressive strength of each specimen and average specimen compressive strength.
 - b. Unit mass for each specimen and average specimen unit mass at time of compressive strength testing.
- B. Prepare delivery tickets containing following information:
 - 1. Project designation.
 - 2. Date.
 - 3. Time.
 - 4. Class and quantity of flowable fill.
 - 5. Actual batch proportions.
 - 6. Free moisture content of aggregate.
 - 7. Quantity of water withheld.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify excavation is complete.
- B. Verify utility installation is complete and tested before placing flowable fill.
- C. Verify excavation is dry and dewatering system is operating, if required.

3.2 PREPARATION

- A. Support and restrain utilities to prevent movement and flotation during installation of flowable fill.
- B. Protect structures and utilities from damage caused by hydraulic pressure of flowable fill before fill hardens.
- C. Protect utilities to prevent intrusion of flowable fill.

3.3 INSTALLATION - FILL, BEDDING, AND BACKFILL

- A. Place flowable fill by chute, pumping or other methods approved by Engineer.
 - 1. When required, place flowable fill under water using tremie procedure.
 - 2. Do not place flowable fill through flowing water.
- B. Place flowable fill in lifts to prevent lateral pressures from exceeding structural capacity of structures and utilities.
- C. Place flowable fill evenly on both sides of utilities to maintain alignment.
- D. Place flowable fill to elevations indicated without vibration or other means of compaction.

3.4 INSTALLATION - FILLING ABANDONED UTILITIES

- A. Perform work in accordance with Standard Specifications and Construction Drawings.
- B. Verify pipes and conduits are not clogged and are sufficiently empty to permit gravity installation of flowable fill for entire length indicated to be filled.
- C. Seal lower end of pipes and conduits by method to contain flowable fill and to vent trapped air caused by filling operations.
- D. Place flowable fill using method to ensure there are no voids.
 - 1. Fill pipes and conduits from high end.
 - 2. Fill manholes, tanks, and other structures from grade level access points.
- E. After filling pipes and conduits seal both ends.

3.5 FIELD QUALITY CONTROL

- A. Perform testing according to ASTM C94/C94M.
 - 1. Take samples for tests for every 150 cu yd of flowable fill, or fraction thereof, installed each day.
 - 2. Sample, prepare and test four compressive strength test cylinders according to ASTM D4832. Test one specimen at 3 days, one at 7 days, and two at 28 days.

3. Measure temperature at point of delivery when samples are prepared.
 - B. Defective Flowable Fill: Fill failing to meet following test requirements or fill delivered without following documentation.
 1. Test Requirements:
 - a. Minimum temperature at point of delivery.
 - b. Compressive strength requirements for each type of fill.
 2. Documentation: Duplicate delivery tickets.
- 3.6 CLEANING
- A. Remove spilled and excess flowable fill from Project Site.
 - B. Restore facilities and Site areas damaged or contaminated by flowable fill installation to existing condition before installation.

END OF SECTION 31 23 24

SECTION 31 25 00 - EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.1 SUMMARY

- A. This section covers work necessary for stabilization of soil to prevent erosion during and after construction and land disturbance activities. The work shall include furnishing all labor, materials, tools, and equipment to perform all work and services necessary for or incidental to the furnishing and installation, complete, of all operations in connection with erosion control as shown on drawings and as specified, in accordance with provisions of the Contract Documents, and completely coordinated with work of all other trades. The Contractor shall insure that all sedimentation features are in place prior to construction as necessary. Contractor shall remove the features as ground cover is established with approval of the Engineer and/or controlling authorities.
- B. The minimum areas requiring soil erosion and sediment control measures are indicated on the Drawings. The right is reserved to modify the use, location, and quantities of soil erosion and sedimentation control measures based on activities of the Contractor and as the Engineer considers to be the best interest of the Owner.
- C. Any governmental agency standard as noted below should be referenced as the latest, most recent, or current version of the referenced standard.
- D. The Contractor shall implement the approved Erosion and Sediment Control plan and follow all state requirements regarding sedimentation and erosion control. Construction methods shall minimize sedimentation and erosion.
- E. See additional information noted on the Drawings.

1.2 DEFINITIONS

- A. NCDOT: North Carolina Department of Transportation
- B. NCDEQ - DEMLR: North Carolina Department of Environmental Quality - Division of Energy, Mineral, and Land Resources.

1.3 GENERAL

- A. See Division 01, "General Requirements," which contain information and requirements that apply to the Work specified herein and are mandatory for this project.
- B. All activities shall conform to the Standard Erosion Control Specification: North Carolina Erosion and Sediment Control Planning and Design Manual, latest version; the NCDEQ erosion control permit; the Specifications; and the Drawings. In the event of a conflict, the more stringent requirement shall apply.
- C. Soil erosion stabilization and sedimentation control shall consist of the following elements:

1. Maintenance of existing permanent or temporary storm drainage piping and channel systems, as necessary.
 2. Construction of new permanent or temporary storm drainage piping and channel systems, as necessary.
 3. Construction of temporary erosion control facilities such as silt fences, inlet protection, etc.
 4. Topsoil, Temporary Seeding, and Sod:
 - a. Placement and maintenance of Temporary Seeding on all areas disturbed by construction, as necessary.
 - b. Placement of permanent topsoil, fertilizer, and sod, etc. in areas as specified on the Drawings.
 5. It is the intent that all areas in which construction activities have disturbed existing vegetation shall be temporarily seeded, as required, topsoiled, and permanently sodded.
- D. The Contractor shall be responsible for phasing Work in areas allocated for his / her exclusive use during this Project, including any proposed stockpile areas, to restrict sediment transport. This will include installation of any temporary erosion control devices, ditches, or other facilities that may be required to comply with NCDEQ-DEMLR regulations and requirements.
- E. The areas set aside for the Contractor's use during the Project may be temporarily developed to provide satisfactory working, staging, and administrative areas for his / her exclusive use. Preparation of these areas shall be in accordance with other requirements contained within these Specifications and shall be done in a manner to both control all sediment transport from the project area, and to permit the area to be returned to design grades and drainage patterns upon completion of the project.
- F. Upon completion of the Project, all areas that have been disturbed by the Contractor shall be stabilized by top-soiling and permanent sodding.
- G. All permanent stockpiles, if any, shall be seeded with soil stabilization seed and protected by construction of two (2) rows of silt fence.
- H. Sediment transport and erosion from working stockpiles shall be controlled and restricted from moving beyond the immediate stockpile area by construction of temporary silt fence, as necessary. The Contractor shall keep these temporary facilities in operational condition by regular cleaning, re-grading, and maintenance.
- I. The Contractor shall maintain all elements of the Soil Erosion Stabilization and Sedimentation Control systems to be constructed during this Project for the duration of his / her activities on this Project. Formal inspections made jointly by the Contractor and the Engineer shall be conducted every 2 weeks to evaluate the Contractor's conformance to the requirements of both these Specifications and NCDEQ regulations.

- J. Maintenance of the Soil Erosion Stabilization and Sedimentation Control systems constructed as part of this project shall be in accordance with the Drawings and NCDEQ Standard Erosion Control Specifications.

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the Specifications, Section 013300, "Submittal Procedures."
- B. In addition, the Contractor shall provide the following specific information:
 - 1. If Contractor plans to vary erosion control phasing from the Drawings, then he / she shall submit a written plan, including definition and locations of phased erosion and sediment control for areas that will be disturbed during staged construction sequences. This information shall be provided to the Engineer and Owner, for review, before commencing any Work on the Project.

1.5 QUALITY ASSURANCE

- A. Perform Work according to NCDEQ and NCDOT standards.

1.6 INSPECTIONS AND RECORD KEEPING

- A. The Contractor is responsible for self-inspection of sedimentation and erosion control devices throughout the life of the Work, including preparation of self-inspection reports and NPDES Self-Monitoring Reports, to make sure the approved erosion and sedimentation control plan is being followed. To simplify documentation of Self-Inspection Reports and NPDES Self-Monitoring Reports, Contractor shall use a combined form available at <http://portal.ncdenr.org/web/lr/erosion>.
- B. Contractor shall refer to Self-Inspection Reports Reporting Requirements on Drawings.
- C. Contractor shall maintain a record keeping box, on-site with a rain gauge, whereby storm water records are kept and are easily accessible for site inspectors.

PART 2 PRODUCTS

2.1 AGGREGATE

- A. Temporary Construction Entrance
 - 1. Contractor shall use 2" – 3" washed stone.
- B. Silt Fence Outlet
 - 1. Contractor shall use #57 washed stone furnished according to NCDOT Standard Specifications for Roads and Structures, latest.

2.2 GEOTEXTILES

A. SEDIMENT FENCE GEOTEXTILE

1. Contractor shall use a synthetic filter fabric of at least 95% by weight of polyolefins or polyester, which is certified by the manufacturer or supplier as conforming to the requirements in ASTM D 6461, which is shown in the table below.
2. Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120°F.

Temporary Silt Fence Material Property Requirements					
	Test Material	Units	Supported ¹ of silt fence	Un-Supported ¹ Silt Fence	Type Value
Grab Strength	ATSM D4632	N (lbs)	400	550	
Machine			MARV		
Direction			(90)	(90)	
x-Machine	ASTM D 4491 MARV	sec-1	400	450	
Direction			MARV		
			(90)	(90)	
Permittivity ²	ASTM D 4491 MARV	mm	0.05	0.05	
Apparent			0.60	0.60	Max.
Opening Size ²					
ARV ³		(US Seive#)	(30)	30)	
		%	70% after	70% after	

¹ Silt Fence support shall consist of 14 gage steel wire with a mesh spacing of 150 mm (6 inches), or prefabricated polymer mesh of equivalent strength.

² These default values are based on empirical evidence with a variety of sediment. For environmentally sensitive areas, a review of previous experience and/or site or regionally specific geotextile tests in accordance with Test Method D 5141 should be performed by the agency to confirm suitability of these requirements.

³ As measured in accordance with Test Method D 4632.

B. CONSTRUCTION ENTRANCE GEOTEXTILE

- Contractor shall use a synthetic geotextile meeting the requirements of a Type 2 engineering fabric shown in Table 1056-1 of the NCDOT Standard Specifications for Roads and Structures, latest.

C. ROLLED EROSION CONTROL BLANKET

- Rolled erosion control blankets shall have a minimum allowable shear stress of 1.5-lbs/ft² and a minimum longevity of 12 months
- Anchoring devices for rolled erosion control blankets shall be minimum 11 gauge staples, 1-in wide, and 6-in long or 12-in minimum length wooden stakes.

2.3 TEMPORARY SLOPE DRAINS

- Temporary slope drains shall be corrugated HDPE pipe.

2.4 SKIMMER BASIN

- Skimmer shall meet the design requirements of the drawings and the Standard Erosion Control Specifications

- B. Porous baffles shall be reinforced coir fiber with a minimum of 700-g/m².

2.5 SEDIMENT FENCE STEEL POSTS

- A. Contractor shall use posts for sediment fences are 1.25 lb./linear ft. minimum steel with a minimum length of 5 feet. Contractor shall make sure that steel posts have projections to facilitate fastening the fabric.

2.6 SEDIMENT FENCE FABRIC REINFORCEMENT

- A. For reinforcement of standard strength filter fabric, Contractor shall use wire fence with a minimum 14 gauge and a maximum mesh spacing of 6 inches.

2.7 PLANTING MATERIALS

- A. Temporary Seeding and Soil Supplements:
 - 1. Furnish according to Standard Erosion Control Specification
- B. Permanent Seeding (if used)
 - 1. Furnish according to Standard Erosion Control Specification
- C. Sod (if used)
 - 1. Furnish according to Standard Erosion Control Specification

PART 3 EXECUTION

3.1 GENERAL

- A. The Contractor shall install erosion and sediment control measures and maintain in accordance with the Drawings, the sequence of construction shown on the Drawings are made a part of these Contract Documents.
- B. The Contractor shall install any additional measures which the Engineer or NCDEQ Inspector may deem necessary to comply with the Standard Erosion Control Specification General Criteria or NCDEQ Erosion Control requirements, at no additional cost to the Owner.
- C. The Contractor shall provide and maintain Temporary Seeding at all times.

3.2 SILT FENCE

- A. Silt fence to be installed as indicated on Drawings and per the Standard Erosion Control Specification. Silt fence to be placed prior to demolition, trench installations, or other clearing activities. Silt fence may be temporarily removed and replaced to facilitate construction.
- B. Maintenance shall be performed per the Standard Erosion Control Specification.

- C. After ground cover has been established and approved by Engineer and NCDENR Erosion Control Inspector, the silt fence shall be removed and disposed of in an approved off-site location at the Contractor's expense.

3.3 SILT FENCE OUTLETS

- A. Install silt fence outlets per the details shown on Drawings and per the Standard Erosion Control Specification.
- B. Maintenance shall be performed per the Standard Erosion Control Specification.
- C. Contractor to verify silt fence outlet placement at low points as they exist or develop. Additional silt fence outlets may be required to prevent erosion during and after construction and land disturbance activities. If additional silt fence outlets are necessary, Contractor to add additional silt fence outlets per Engineer, NCDEQ Erosion Control Inspector, or Owner direction.

3.4 TEMPORARY DIVERSION DITCHES AND SLOPE DRAINS

- A. Install temporary diversion ditches as shown on the drawings, details and per the Standard Erosion Control Specification.
- B. Where shown on the drawings, install rolled erosion control blankets and rock check dams per the details and the Standard Erosion Control Specification.
- C. Install temporary slope drains per the drawings and the Standard Erosion Control Specification where runoff from diversion ditches enters the sediment basins, as shown on the drawings.
- D. Maintenance shall be performed per the Standard Erosion Control Specification.

3.5 SKIMMER BASINS

- A. Install skimmer basins as shown on the drawings per the details and the Standard Erosion Control Specification.
- B. Permanent stormwater management devices that are temporarily used as skimmer basins shall be constructed per the drawings, details and specifications of the final stormwater management facility.
- C. Maintenance shall be performed per the Standard Erosion Control Specification.

3.6 INLET PROTECTION

- A. Install Inlet Protection per the detail shown on Drawings and per the Standard Erosion Control Specification.
- B. Inlet protection shall be placed at the upstream side of any pipe or structure discharging outside of the disturbed limits. See Drawings for location.

3.7 CONSTRUCTION ENTRANCE

- A. Install construction entrance per the detail shown on Drawings and per the Standard Erosion Control Specification.
- B. Shall be maintained in a condition to prevent tracking or direct flow of mud onto adjacent roadways.

3.8 STOCKPILES

- A. Install stockpiles per the detail shown on Drawings and per the Standard Erosion Control Specification.
- B. Stockpile height shall not to exceed 15 feet and side slopes shall be 2 (H) to 1 (V) or flatter.
- C. Stockpile shall have a minimum double row of silt fence as shown on Drawings.

3.9 GROUND STABILIZATION

- A. Contractor shall provide ground stabilization per the Standard Erosion Control Specification and in accordance with the table below
- B.

Site Area Description	Stabilization Time Frame	Stabilization Time Frame Exceptions
Perimeter Dikes, Swales, Ditches, and Slope	7 Days	None
High Quality Water (HQW) Zones	7 Days	None
Slopes Steeper Than 3:1	7 Days	If Slopes are 10' or less in length and are not steeper than 2:1, 14 Days
Slopes 3:1or Flatter	14 Days	7-Days for slopes greater than 50-ft in length
All other areas with slopes flatter than 4:1	14 Days	None (except for perimeters and HQW zones)

3.10 TEMPORARY SEEDING

- A. Temporary Seeding is to be placed and maintained over all disturbed areas prior to Permanent Sodding per the detail shown on Drawings and per the Standard Erosion Control Specification
- B. Maintain Temporary Seeding until such time as areas are approved for permanent seeding. As a minimum, maintenance shall include the following:
 - 1. Fix-up and reseeding of bare areas or re-disturbed areas.
 - 2. Mowing for stands of grass or weeds exceeding 6 inches in height.

END OF SECTION 31 25 00

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes soil treatment for termite control.

1.3 ACTION SUBMITTALS

- A. Product Data: Treatments and application instructions, including EPA-Registered Label.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Signed by manufacturers of termite control products certifying that treatments furnished comply with requirements of the N.C. Dept. of Agriculture, Structural Pest Control Division.
- B. Qualification Data: For applicator.
- C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's record information, including the following as applicable:
 - 1. Date and time of application.
 - 2. Moisture content of soil before application.
 - 3. Brand name and manufacturer of termiticide.
 - 4. Quantity of undiluted termiticide used.
 - 5. Dilutions, methods, volumes, and rates of application used.
 - 6. Areas of application.
 - 7. Water source for application.
- D. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

- A. Applicator Qualifications: A Pest Control Operator who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment in jurisdiction where Project is located and who is experienced and has completed termite control treatment similar to that indicated for this Project and whose work has a record of successful in-service performance.
- B. Regulatory Requirements: Formulate and apply termiticides, and label with a Federal registration number, to comply with EPA regulations and authorities having jurisdiction.

- C. Standards for Application: Current edition of North Carolina Administrative Code 2:34.0506 and North Carolina Structural Pest Control Committee Rules and Regulations.
- D. Source Limitations: Obtain termite control products from single manufacturer for each product.
- E. Testing: If required by the Architects Construction Administrator or Owner, the Contractor shall contact the NC Department of Agriculture to have treated soil tested to verify application compliance. Allow a minimum of 2 days notice to schedule inspection.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with EPA-Registered Label requirements and requirements of authorities having jurisdiction.

1.7 COORDINATION

- A. Coordinate soil treatment application with excavating, filling, and grading and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs, before construction.

1.8 WARRANTY

- A. Special Warranty: Written warranty, signed by applicator and Contractor certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

- 1. Warranty Period: Five years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

- A. Continuing Service: Provide a proposal for a lifetime warranty, including monitoring, inspection, and retreatment for occurrences of termite activity, from applicator to Owner, in the form of a continuing bond agreement, starting on the date of Final Acceptance. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

- A. Termiticide: Provide an EPA-registered non-repellent liquid termiticide, complying with requirements of state and local authorities having jurisdiction, in a soluble or emulsible concentrated formulation that dilutes with water or foaming agent, and formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to the product's EPA-Registered Label.

1. Use only soil treatment solutions that are not harmful to plants.
 2. Use compatible dye in termiticide to provide visible evidence of treatment.
 3. Service Life of Treatment: Soil treatment termiticide that is effective for not less than-15 years against infestation of subterranean termites.
- B. Manufacturers: Subject to compliance with requirements of the N.C. Dept. of Agriculture, Structural Pest Control Division, provide products by one of the following:
1. BASF (Termidor – Preferred alternate PA-11)
 2. AgrEvo Environmental Health, Inc.
 3. Bayer Corp.
 4. Dow AgroSciences.
 5. FMC Corp.
 6. Zeneca Ag Products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of the soil, interfaces with earthwork, slab and foundation work, landscaping, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparing substrate. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended by termiticide manufacturer.
- C. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

3.3 APPLICATION, GENERAL

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.

3.4 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute the treatment evenly.
 - 1. Slabs-on-Grade: Underground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 - 2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
 - 3. Masonry: Treat voids.
 - 4. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.
- B. Post warning signs in areas of application.
- C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner may engage a qualified independent testing agency to perform field quality-control testing and provide report to Architect.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer receiving termiticide treatment. Proceed with subsequent work only after inspections for previously completed work comply with requirements.
- C. When testing agency reports that subgrades, fills, or backfills have not been adequately treated with termiticide, reapply treatment and retest until specified treatment has been achieved.

3.6 PROTECTION

- A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- B. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

END OF SECTION 313116

SECTION 32 12 16 - ASPHALT PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-mix asphalt paving.
 - 2. Hot-mix asphalt paving overlay.
 - 3. Asphalt surface treatments.
 - 4. Pavement-marking paint.
- B. Related Sections:
 - 1. Section 312000 "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.

1.3 DEFINITION

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 and Standard Specifications of North Carolina Department of Transportation (NCDOT) for definitions of terms.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
 - 1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
- B. Shop Drawings: Indicate pavement markings and lane separations.
- C. Material Certificates: For each paving material, from manufacturer.
- D. Material Test Reports: For each paving material.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by NCDOT.
- B. Installer Qualifications: Imprinted-asphalt manufacturer's authorized installer who is trained and approved for installation of imprinted asphalt required for this Project.
- C. Testing Agency Qualifications: Qualified according to ASTM D 3666 and NCDOT for testing indicated.

- D. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the NCDOT Standard Specifications (latest version) and the City of Wilmington for asphalt paving work.
 - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.
- E. Pre-installation Conference: Conduct conference at Project Site.
 - 1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
 - a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
 - b. Review condition of subgrade and preparatory work.
 - c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
 - d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
- F. Contractor shall provide and conduct a quality control program as defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of the pavement in accordance with NCDOT's "Hot Mix Asphalt Quality Management System" (HMA / QMS) manual which is in force on the date of the contract advertisement.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if base is frozen, wet or excessively damp, if rain is imminent or expected before time required for adequate cure, in accordance with Table 610-3 from the NCDOT Standard Specifications.
- B. Pavement-Marking: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 PRODUCTS

2.1 AGGREGATES

- A. Coarse Aggregate, Fine Aggregate, and Mineral Filler

1. In accordance with the requirements of Section 520 NCDOT Standard Specifications and the Drawings.

2.2 ASPHALT MATERIALS

- A. All materials utilized in the production of hot mix asphalt shall meet NCDOT applicable requirements of the provisions from Section 610 titled "Asphalt Concrete Plant Mix Pavement," for the type of Superpave plant mix pavement specified on the Drawings.

2.3 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by NCDOT; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
 1. Types SF-9.5A and S-9.5B.

2.4 DESIGN SECTIONS

- A. All sections shall be in accordance with pavement recommendations.
- B. Light Duty: 2-inches of Surface S-9.5B over 8-inches of compacted ABC Stone subgrade.
- C. Heavy Duty: 3-inches of Surface S-9.5B over 8-inches of compacted ABC stone subgrade.
- D. Rigid: 6-inches of 4,000 psi concrete over 4 inches of compacted ABC stone.

2.5 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: MPI #32 Alkyd Traffic Marking Paint.
 1. Color: As indicated.
- B. Pavement-Marking Paint: MPI #97 Latex Traffic Marking Paint.
 1. Color: As indicated.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verify that base course is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with a heavy vibratory smooth drum roller, having a weight of at least 10 tons, making repeated passes over the subject area to identify soft pockets and areas that rut, pump or deflect excessively. Proof-rolling shall be observed and areas repaired as recommended by Owner's Testing Agency prior to paving. Do not proof-roll wet or saturated base course.
 1. Completely proof-roll base course in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.

2. Excavate soft spots, unsatisfactory stone and/or soils, and areas of excessive pumping or rutting, as determined by Owner's Testing Agency, and replace with compacted ABC stone or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected and verified by Owner's Testing Agency.

3.2 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared base course is ready to receive paving.
- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared surface of compacted-aggregate base before applying paving materials.
- C. Tack Coat: Apply uniformly to surfaces of existing pavement and abutting concrete surfaces at a rate of 0.05 to 0.15 gal./sq. yd.
 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.3 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off in accordance with NCDOT requirements. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted per Drawings.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.
- D. Mix and environmental temperatures should be in accordance with NCDOT requirements and should be documented the Owner's Testing Agency by NCDOT certified technicians.

3.4 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
 1. Clean contact surfaces and apply tack coat to joints.
 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.

3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.5 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted as follows:
 1. Target Average Density (S-9.5B): 92 percent of theoretical maximum density according to AASHTO T166, T275, or T331, with no individual test less than 90 percent nor greater than 100 percent.
 2. Target Average Density (SF-9.5A): 90 percent of theoretical maximum density according to AASHTO T166, T275, or T331, with no individual test less than 88 percent nor greater than 98 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness. Cutting and patching of newly placed asphalt is unacceptable. If defective asphalt is discovered, milling of asphalt and replacement with new asphalt will be required.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.6 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Initial Course: Plus or minus 1/2 inch or per NCDOT requirements, whichever is more stringent.
 - 2. Surface Course: Plus 1/4 inch, no minus or per NCDOT requirements, whichever is more stringent.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Initial Course: 1/4 inch.
 - 2. Surface Course: 1/8 inch.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.7 PAVEMENT MARKING

- A. Apply temporary traffic marking paint – Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three minutes.
- B. Permanent Pavement Markings – Thermoplastic Composition shall be placed in accordance with NCDOT specifications.
 - 1. Thermoplastic Alkyd/Maleic and Hydrocarbon pavement markings shall be composed of the following materials:

COMPONENT BY WEIGHT

Alkyd/Maleic Binder	18.0%	Min.
Hydrocarbon Binder	22.0%	Min.
Glass Beads (Premixed)	30.0%	Min.
Titanium Dioxide (ASTM D-476, Type 2).....	10.0%	Min.
Yellow Pigment (For Yellow Marking Only)	4.0%	Min.

- 2. Calcium carbonate and inert fillers shall be opted by the manufacturer, providing all other specifications are met.

3. The total silica content used in the formulation of the thermoplastic shall be the premixed glass beads.
4. The pigment, beads, and filler shall be uniformly dispersed in the binder.
5. The Alkyd/Maleic binder shall consist of a mixture of synthetic resins (at least on synthetic resin shall be solid at room temperature) and high boiling point plasticizers. At least one-third of the binder composition shall be 100% maleic-modified glycerol ester of resin and shall be no less than 10% by weight of the entire material formulation. The binder shall contain no petroleum Hydrocarbon resins, tall oil resins or rosins, or any combination of tall oil resins with maleic- modified glycerol esters of rosin.
6. The Hydrocarbon binder shall consist of a mixture of Hydrocarbon resins (at least one Hydrocarbon resin shall be solid at room temperature) and high boiling point plasticizers.
7. The thermoplastic material shall be free of contaminates and shall be dry blended or hot mixed from 100% virgin stock using no reprocessed materials.
8. The thermoplastic material shall be formulated such that when it is on the roadway surface at any natural temperature it exists in a hard, solid state with cold ductility that permits normal movement with the road surface without chipping or cracking.
9. The thermoplastic material shall not deteriorate or discolor when held at the application temperature for periods of time up to 4 hours or upon repeated reheating (a minimum of 4 times).
10. The color, viscosity, and chemical properties versus temperature characteristics of the thermoplastic material shall remain constant for up to 4 hours at the application temperature and shall be the same from batch to batch.
11. The thermoplastic material shall be readily applicable at temperatures between 400 & 440 degrees F from the approved equipment to produce lines and symbols of the required above the pavement thickness.

C. Pavement-Marking Paint

1. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner.
2. Allow paving to age for 30 days before starting pavement marking.
3. Sweep and clean surface to eliminate loose material and dust.
4. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.8 FIELD QUALITY CONTROL

- A. Contractor is responsible for quality control in accordance with NCDOT's "Hot Mix Asphalt Quality Management System" (HMA/QMS) manual including, but not limited to thickness, smoothness, and in-place density.
- B. Contractor is responsible for providing Owner's Testing Agency with theoretical daily moving average from plant for each day's placement and each mix type placed during that day.
- C. Testing Agency: Owner's Testing Agency will core a minimum of three locations for each day's placement per mix type. The cores will be evaluated by the Owner's Testing Agency for thickness and compaction.
- D. Contractor to replace and compact hot-mix asphalt where core tests were taken.
- E. Remove and replace hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.9 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
 - 1. Do not allow milled materials to accumulate on-site.

END OF SECTION 321216

SECTION 32 13 13 - CONCRETE PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes exterior cement concrete pavement for the following:
 - 1. Curbs and gutters.
 - 2. Walkways.
- B. Related Sections:
 - 1. Section 033000, "Cast-in-Place Concrete"
 - 2. Section 312000, "Earth Moving"

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 SUBMITTALS

- A. Product info: Data, Test Reports, and Material Certifications for each type of product indicated as required in Section 033000.
- B. Furnish drawings indicating jointing pattern proposed for all areas of concrete pavement for approval by the Engineer. Only information completely checked by the manufacturer and the General Contractor will be considered by the Engineer.

1.5 QUALITY ASSURANCE

- A. Products and methods of execution are specified by reference to North Carolina State Department of Transportation and Highway Safety's "Standard Specifications for Roads and Structure" (latest edition). The abbreviation NCDOT is used to designate this publication. Equivalent alternate products and methods of execution as defined by the specifications. All methods and substitutions must be approved by the Engineer.
- B. Testing: The Owner's Testing Agency will evaluate concrete delivered to and placed at the site in accordance with requirements of Section 033000.
- C. Pre-installation Conference: Conduct conference at the Project Site.
 - 1. Review methods and procedures related to concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.

- b. Quality control of concrete materials and concrete paving construction practices.
- 2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete paving subcontractor.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 PRODUCTS

2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces. Forms shall remain in place for a minimum of 24 hours after concrete placement or until concrete is secure. Use straight forms, free of distortion and defects, extending the full depth of concrete. All forms shall receive a form coating the full depth of concrete per Section 033000 of these specifications prior to placing concrete.
 - 1. 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.
- C. Automatic Machine Curb and Gutter
 - 1. Automatic machine may be used for curb and gutter placement at Contractor's option. If machine placement is to be used, Contractor shall submit revised mix design and laboratory test results which meet or exceed minimums specified.
 - 2. Machine placement must produce curb and gutters to required cross-section, line grades, finish, and jointing as specified for formed concrete. If results are not acceptable, Contractor shall remove and replace with formed concrete as specified.

2.2 STEEL REINFORCEMENT

- A. Recycled Content: Provide steel reinforcement with an average recycled content of steel so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
- B. Plain-Steel Welded Wire Reinforcement: ASTM A-185, fabricated from steel wire into flat sheets.

- C. Tie Bars: ASTM A 615, Grade 60, deformed.
- D. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
 - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
 - 2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- F. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

2.3 CONCRETE MATERIALS

- A. Concrete: Concrete and equipment, workmanship and materials for forming shall conform to applicable requirements of Section 033000, unless otherwise specified. Concrete shall be standard weight with minimum compressive strength as specified on the construction drawings for the various applications.

2.4 CURING MATERIALS

- A. Curing Compound shall be:
 - a. "Clear Bond" by Guardian Chemical Company
 - b. "Sealkure" by Toch Brothers, Inc.
 - c. "Klearseal" by Penn-Dixie or equivalent

2.5 RELATED MATERIALS

- A. Expansion Joint Fillers: Expansion joint fillers shall be ½ inch thick unless otherwise shown on Drawings, equivalent to and shall conform to NCDOT Section 1028:
 - 1. Celotex "Flexcell", "Fibre", by W.R. Meadows
 - 2. "Tex-Lite", by K & P Petroleum Products
 - 3. Sonneborn Sonolastic Sealant
- B. Joint Sealer: Silicone sealant as manufactured by Surebond Inc., WR Meadows, Dow Corning, Silka Corporation or equivalent.

2.6 DETECTABLE WARNING MATERIALS

- A. In accordance with City of Wilmington standards and details.

2.7 CONCRETE MIXTURES

- A. Concrete mixture shall conform to applicable requirements of Section 033000.
- B. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with Owner requirements.

2.8 CONCRETE MIXING

- A. Concrete mixing shall conform to applicable requirements of Section 033000.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
 - 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
 - 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected and approved by the Engineer or Owner's Testing Agency.

3.2 PREPARATION

- A. Remove loose material from compacted base or subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.
- F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963.
- G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Provide tie bars at sides of paving strips where indicated.
 - 3. Butt Joints: Use a bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 2 inches into concrete.
 - 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where

indicated.

1. Locate $\frac{1}{2}$ inch expansion joints at intervals of 30 feet unless otherwise indicated.
 2. Extend joint fillers full width and depth of joint.
 3. Terminate joint filler not less than $\frac{1}{2}$ inch or more than 1 inch below finished surface if joint sealant is indicated.
 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. For concrete walks provide contraction joints at 5'-0" (max) o.c., unless otherwise shown on Drawings. For curb and gutter, joints shall be in accordance with the Drawing detail. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
 - a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.
 2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing

concrete.

- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.
- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing. Curbs shall be true, straight, and of uniform level and slope. All construction shall conform to NCDOT Section 846 and applicable requirements therein. The concrete shall be given a light broom finish with brush marks parallel to the curb line or gutter line.
- K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.
- L. Cold-Weather Placement: Refer to Section 033000 "Cast in Place Concrete"
- M. Hot-Weather Placement: Refer to Section 033000 "Cast in Place Concrete"
 - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations. Finishing operations shall conform to the requirement of NCDOT Section 710.

3.8 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Immediately after finishing operations, cure exposed concrete surfaces in accordance with NCDOT Section 700.
- F. After curing, remove debris and backfill area adjoining sidewalk and paving. Grade and compact to conform to surrounding area in accordance with lines and grades indicated on Drawings. Remove damaged concrete that does not drain properly and reconstruct at no additional cost to Owner.

3.9 FIELD QUALITY CONTROL

- A. Sampling: See Section 033000 "Cast-in-Place Concrete" for testing requirements.

3.10 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Engineer.
- B. Drill test cores where directed by Engineer or Owner's Testing Agency, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with Portland cement concrete bonded to paving with epoxy adhesive. See Section 033000 "Cast-In-Place Concrete" for testing requirements.
- C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

SECTION 32 92 00 - TURF AND GRASSES

PART 1- GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding: All disturbed areas other than those specifically shown to receive sod on the construction drawings, shall be seeded.
2. Sodding: See Construction Documents for limits of sodding.

1.2 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. Planting Area: Areas to be planted.
- G. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.
- H. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.
- I. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.3 SCOPE

- A. Contractor is to provide and install topsoil, provide soil preparation and provide and install turf and grass areas.
- B. Contractor is to scarify subgrade in coordination with and prior to installation of any imported topsoil in order to mix the soil profiles.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Certification of grass seed.
 - 1. Certification of each seed mixture for turfgrass sod.
 - 2. Certification of each temporary seed mixture for slopes.
- C. Product certificates.
- D. Planting Schedule: Indicating anticipated planting dates for each type of planting.
- E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
- B. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory.
 - 1. Report suitability of topsoil for lawn growth. State-recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

1.6 MAINTENANCE SERVICE

- A. Initial Lawn Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3.7. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
 - 1. Seeded Lawns: Through date of final acceptance by Owner.
 - a. When initial maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.
 - 2. Permanent Seed Mix Areas: One year from installation.
 - a. When initial maintenance period has not elapsed before end of planting season, or if seed mix areas are not fully established, continue maintenance during next planting season.
 - 3. Sodded Lawns: 30 days from final acceptance by Owner.

PART 2 PRODUCTS

2.0 TURFGRASS SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed

Technology; Rules for Testing Seeds" for purity and germination tolerances.

- B. Seed Species: State-certified seed of grass species, as follows: Celebration Bermuda or equal.

2.1 TURFGRASS SOD

- A. Turfgrass Sod: Complying with TPI's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
- B. Sod Species: State-certified sod of grass species, as follows: Celebration Bermuda or equal.

2.2 TOPSOIL

- A. Topsoil is to be provided for in the contract and installed by the contractor prior to the site being turned over to Owner. The designer shall approve all topsoil prior to installation. The contractor shall provide soil tests for any topsoil brought onto the site, and obtain approval from the University before delivery. The contractor shall insure that all topsoil is screened so that it contains no material larger than 1.0 inches in diameter or length and shall not contain slag, cinders, stones, lumps of soil, sticks, roots, trash, or other extraneous materials the contractor shall insure topsoil is free of plants or plant parts of bermuda grass, johnson grass, nut sedge, poison ivy, or other noxious weeds.
- B. Topsoil should be purchased pre-mixed or mixing should be done off site prior to soil testing unless otherwise approved by engineer.
 - 1. Soil shall be a mixture of eight parts topsoil, thoroughly mixed with three parts peat humus and one part weed seed free manure.
 - 2. For non-ericaceous plants, topsoil shall have a pH range between 5.8 and 6.5, total soluble salts not to exceed 500 parts per million, and clay content shall range between 5% and 25%.

2.3 FERTILIZER

- A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium. Depending on soil analysis select one of the following compositions: (Provide copy of soil test to UNCW)
 - 1. 18-16-12.
 - 2. 24-6-12.

2.4 MULCHES

- A. Fresh, long needle pine straw at a depth of 4". Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

PART 3 EXECUTION

3.0 TOPSOIL INSTALLATION

- A. Contractor is responsible for installation of topsoil and incorporating soil amendments and fertilizers in the quantities per results of the topsoil analysis. Scarify and loosen subgrade to integrate imported topsoil with subgrade. Install 6" of topsoil in areas to be seeded or sodded.
- B. Prior to topsoil application, the contractor shall scarify the soil areas where topsoil is to be applied to a depth of six inches (6") and remove and haul off all construction debris before spreading the topsoil. No scarification or subsoiling should be done within the dripline of any existing tree. The topsoil needs to be mixed into the scarified top layer of existing soil. Continue adding soil in 2"-4" lifts until finish grade is established. A minimum of six inches (6") of topsoil is to be applied in all disturbed areas. Exceptional care should be taken when spreading topsoil around trees. Soil around existing trees should not exceed the grade which existed prior to construction. Grade lawn areas and beds to conform to finish grades and profiles indicated on drawings, assuring uninterrupted drainage pattern, free of hollows and pockets. In areas where subgrade is poorly drained, provide corrective drainage indicated on drawings. If these measures do not correct drainage notify engineer for his direction prior to further work.
- C. Clean Up - After the soils have been ripped, and before the required topsoil is spread, and final grades approved, clear the site of all surface trash and other objects that will hinder the installation and maintenance of the planted areas. The clean-up includes plant bed areas, lawn areas, rights-of-way adjacent to the site, buffer areas, and lay down areas.

3.2 STABILIZATION (SEEDING) OF DISTURBED AREAS

- A. Repair and seed all areas that are disturbed during construction. Till disturbed area to a depth of 6 inches. Incorporate 18-24-12 fertilizer at a rate of 10 lb. Per 1000 square feet. Evenly distribute turf type fescue blend grass and perennial rye seed at a rate of 10 lb. Per 1000 square feet. Lightly rake seeded areas, mulch with 1" clean wheat straw, and water thoroughly. Areas that will be converted to plant beds can be stabilized using pine straw or organic mulch.

3.3 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across angle of slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:3 with or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.4 LAWN MAINTENANCE

- A. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations until date of building acceptance by Owner. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn. Provide materials and installation the same as those used in the original installation.
- B. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings.
- C. Mow and maintain until owner acceptance or through maintenance periods established in 1.6 above.

3.5 SATISFACTORY LAWNS

- A. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with total grass coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches, with at least 60% of the total grass coverage consisting of Fescue.
- B. Use specified materials to reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

END OF SECTION 32 92 00

SECTION 32 93 00 - PLANTS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Trees
 - 2. Shrubs
 - 3. Ornamental Grasses & Groundcover
 - 4. Plants
 - 5. Mulches
- B. Related Sections:
 - 1. See "Turfs and Grasses" for lawn planting.

1.2 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- D. Finish Grade: Elevation of finished surface of planting soil.
- E. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- F. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- G. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

- H. Planting Area: Areas to be planted.
- I. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.
- J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk
- K. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.
- L. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.3 SCOPE

- A. Contractor is to provide and install topsoil, provide soil preparation, provide and install mulch, and provide and install plant material.
- B. Contractor is to scarify subgrade in coordination with and prior to installation of any imported topsoil in order to mix the soil profiles.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Product certificates.
- C. Affidavit: From nursery certifying that furnished trees meet the requirements specified under Section 2.
- D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year.

1.5 QUALITY ASSURANCE

- A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
- B. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory.
 - 1. Report suitability of topsoil for plant growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.
- C. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do

not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery and handling.

- B. Handle planting stock by root ball. Use extreme caution when handling trees. Use a chain cradle or strap cradle attached to the root ball to unload and move trees. Do not move, lift or handle by attaching to or putting pressure on the trunk. Do not damage or scar trunks or branches.
- C. Deliver exterior plants after preparations for planting have been completed and install immediately. Immediately after unloading (no more than one hour after unloading), stand the trees up to reduce the risk of sun scald. Properly staged trees are standing, untied and spaced. If planting is delayed more than six hours after delivery, set exterior plants and trees in shade, protect from weather and mechanical damage, and keep roots moist.
- D. Bulk Materials
 - 1. Do not dump or store bulk materials near structures, utilities, walkways, and pavements, or on existing pavements, walkways, turf areas or plants.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Topsoil: If no topsoil is available onsite, all planting soil mixes will require offsite topsoil to be imported at contractor's expense. Mix per the blend specifications.

1.8 WARRANTY

- A. Special Warranty: Installer's standard form in which Installer agrees to repair or replace plantings that fail in materials, workmanship, or growth within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, abuse by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.
 - 2. Warranty Periods from Date of Substantial Completion:
 - c. Trees and Shrubs: One year.
 - d. Ornamental Grasses, Plants, and Groundcovers: One year.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Plantings: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3.8. Begin maintenance immediately after each area is planted and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below.
 - 1. Maintenance Period: One year from date of final acceptance by owner.
 - 2. Deteriorated or dead landscape material shall be repaired or replaced at contractors expense prior to the end of the maintenance period.

PART 2 PRODUCTS

2.1 ORNAMENTAL TREE AND SHRUB MATERIAL

- A. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
- B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1.
- C. Provide balled and burlapped or container-grown trees as indicated on Plant Schedule. Balled and burlapped (B&B) plant material in foliage must be sprayed with anti-desiccant immediately after digging to prevent dehydration.
- D. Shrub sizes indicated on Plant Schedule are sizes after pruning.

2.2 SHADE AND CANOPY TREES

- A. General: Furnish Field-grown trees complying with ANSI Z60.1, with healthy root systems developed by root pruning and transplanting. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement. Furnish trees with the following characteristics:
 - 1. Root System Development
 - a. Trees shall have been field grown in heavy clay soil and irrigated with drip irrigation.
 - b. Trunk flare shall be visible above ground from the nursery.
 - 2. Canopy Development
 - a. Strong Central Leader to the top of the canopy. The tip of the leader on the main trunk must be intact and its terminal bud must be the highest part of the tree.
 - b. No branch shall have a diameter greater than 2/3 the trunk diameter measured directly above the branch crotch.
 - c. The tree crown must be structurally uniform. Branches shall be evenly distributed around the trunk. The crown shall be full of foliage which is evenly distributed around the tree.

- B. Root-Ball Depth: Furnish Trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1.
- C. Provide balled and burlapped trees as indicated on Plant Schedule.

2.3 ORNAMENTAL GRASSES AND GROUNDCOVERS

- A. Ground Cover: Provide ground cover of species indicated, established and well rooted in pots or similar containers, and complying with ANSI Z60.1.

2.4 PLANTS

- A. Annuals: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.
- B. Perennials: Provide healthy, field-grown plants from a commercial nursery, of species and variety shown or listed, complying with requirements in ANSI Z60.1.
- C. Vines: Provide vines of species indicated complying with requirements in ANSI Z60.1.

2.5 TOPSOIL

- A. Topsoil is to be provided for in the contract and installed by the contractor prior to the site being turned over to Owner. The designer shall approve all topsoil prior to installation. The contractor shall provide soil tests for any topsoil brought onto the site, and obtain approval from the University before delivery. The contractor shall insure that all topsoil is screened so that it contains no material larger than 1.0 inches in diameter or length and shall not contain slag, cinders, stones, lumps of soil, sticks, roots, trash, or other extraneous materials the contractor shall insure topsoil is free of plants or plant parts of bermuda grass, johnson grass, nut sedge, poison ivy, or other noxious weeds.
- B. Topsoil should be purchased pre-mixed or mixing should be done off site prior to soil testing unless otherwise approved by engineer.
 - 1. Soil shall be a mixture of eight parts topsoil, thoroughly mixed with three parts peat humus and one part weed seed free manure.
 - 2. For non-ericaceous plants, topsoil shall have a pH range between 5.8 and 6.5, total soluble salts not to exceed 500 parts per million, and clay content shall range between 5% and 25%.

2.8 FERTILIZER (As needed per soil tests. Avoid runoffs into stormwater system.)

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb./1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

- 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

2.9 MULCHES

- A. Fresh, long needle pine straw at a depth of 4".
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m.

2.10 PLANTING SOIL MIX

Unamended topsoil rarely meets the definition of "planting soil." Consult soil experts on how to modify and fertilize topsoil to obtain an acceptable planting soil mix for site conditions and particular plant species.

- A. Planting Soil Mix: Mix topsoil with the soil amendments and fertilizers in the quantities per the results of the topsoil analysis.
- B. Soil Texture:
 - 1. Sand - 60%
 - 2. Clay - 15%
 - 3. Silt - 25%

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid has been deposited in soil within a planting area.
 - 2. Proceeded with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Engineer's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 TOPSOIL INSTALLATION

- A. Contractor is responsible for installation of topsoil and incorporating soil amendments and fertilizers in the quantities per results of the topsoil analysis. Scarify and loosen subgrade to integrate imported topsoil with subgrade. Install 12" of topsoil in all new planting bed locations containing trees and shrubs.
- B. Prior to topsoil application, the contractor shall scarify the soil areas where topsoil is to be applied to a depth of twelve inches (12") and remove and haul off all construction debris before spreading the topsoil. No scarification or subsoiling should be done within the dripline of any existing tree. The first 4" of topsoil needs to be mixed into the scarified top layer of existing soil. Continue adding soil in 4" lifts until finish grade is established. A minimum of twelve inches (12") of topsoil is to be applied in all planting beds. A minimum of twelve inches (12") of topsoil is to be applied in all landscape plant bed areas. Exceptional care should be taken when spreading topsoil around trees. Soil around existing trees should not exceed the grade which existed prior to construction. Grade lawn areas and beds to conform to finish grades and profiles indicated on drawings, assuring uninterrupted drainage pattern, free of hollows and pockets. In areas where subgrade is poorly drained, provide corrective drainage indicated on drawings. If these measures do not correct drainage notify engineer for his direction prior to further work.
- C. Clean Up - After the soils have been ripped, and before the required topsoil is spread, and final grades approved, clear the site of all surface trash and other objects that will hinder the installation and maintenance of the planted areas. The clean-up includes plant bed areas, lawn areas, rights-of-way adjacent to the site, buffer areas, and lay down areas.

3.4 TREES AND SHRUBS

- A. Excavation of Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.
 - 1. Excavate the planting hole width to be 3 times the root ball diameter in highly compacted soil or clay soil and 2 times that root ball diameter minimum in other soil structures.
- B. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. Remove any plastic and circling roots from root ball.
- C. Stock with Root Balls: Set trees and shrubs plumb and in center of pit or trench. The top of root balls should be 2" above adjacent finished grade after settling for trees and large shrubs and 1" above for small shrubs in pots 3 gallons or less.
 - 1. Balled and Burlapped: Remove burlap and wire baskets from one-third (1/3) of root balls, but do not remove from under root balls. Remove burlap once tree is half backfilled and plumb. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 - 2. Container Grown: Carefully remove root ball from container without damaging root ball or plant.
 - 3. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate

voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

- D. Organic Mulching: Apply 3-inch average thickness of organic mulch extending to edge of planting pit or trench. Do not place mulch within 3 inches of trunks or stems.

3.5 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character.

3.6 ORNAMENTAL GRASS, PLANTS, AND GROUND COVER PLANTING

- A. Set out and space ground cover and plants as indicated.
- B. Dig holes large enough to allow spreading of roots and backfill with planting soil.
- C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- E. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.7 PLANTING BED MULCHING

- A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches. Tape or pin seams as recommended by manufacturer.
- B. Mulch backfilled surfaces of planting beds and other areas indicated. Apply a 4-inch thick layer of mulch around plants to help discourage weeds. For trees an area two feet in diameter for each inch of tree trunk diameter (minimum diameter should be eight feet for trees with a trunk diameter less than 3 inches) should be maintained during the establishment period. When mulching trees, apply a 4" layer over the outer half of the root ball. This keeps the trunk dry and allows rainwater, irrigation, and air to easily enter the root ball.
 - 1. Organic Mulch: Apply 3-inch average thickness of mulch, and finish level with adjacent finish grades. Do not place mulch against plant stems hold back mulch on base of trunk 2 inches on all sides.

3.8 PLANT MAINTENANCE

- A. Tree and Shrub Maintenance: Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease. If waterbags are used they shall be of the type that are attached to the trunk and sit vertically when full. No flat bags that

cover the root ball will be allowed.

- B. Ornamental Grasses, Groundcover, and Plant Maintenance: Maintain and establish plantings by watering, weeding, fertilizing, mulching, and other operations as required to establish healthy, viable plantings.
- C. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

3.9 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.10 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 32 93 00

SECTION 33 11 16 – FACILITY WATER DISTRIBUTION

PART 1 GENERAL

1.1 GENERAL NOTES

- A. Work in this section includes exterior water piping and appurtenances for fire main and domestic service at and below the finished grade and up to 5 feet outside the limits of the building. All service connections to the building to be plugged and marked.
- B. All structures, related piping and accessories shall be in accordance with the standards of the North Carolina Department of Public Health, National Fire Protection Association, National Standard Plumbing Code, and supplemented with any applicable Cape Fear Public Utility Authority standards. If discrepancies exist they should be brought to the Engineer's attention immediately.
- C. Refer to construction drawings for number, location and details of all proposed structures and pipes.
- D. Pipes 4 inches and larger shall be Ductile Iron unless otherwise specified.

1.2 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. Materials, Installation, and Testing shall be in accordance with Cape Fear Public Utility Authority and Owner standards and specifications.

1.3 SUMMARY

- A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:
 - 1. Plastic Pipe (PVC & HDPE).
 - 2. Ductile Iron Pipe.
 - 3. Fittings and Specials.
 - 4. Fire Hydrants.
 - 5. Valves.
 - 6. Indicator Posts.
 - 7. Protective Enclosures.
 - 8. Service Connection Pipe and Fittings.
 - 9. Tapping Sleeve and Valves.

10. Pipe Location Wire.
11. Backflow Preventers.
12. Protective Backflow Enclosures.
13. 2" Blow-off Assembly

B. Related Sections: The following Sections contain requirements that relate to the Section:

1. Division 31, Section "Trenching"
2. Division 31, Section "Dewatering"

1.4 DEFINITIONS

- A. PVC: Polyvinyl Chloride Pipe.
- B. DIP: Ductile Iron Pipe.
- C. CFPUA: Cape Fear Public Utility Authority
- D. HDPE: High Density Polyethylene Pipe.

1.5 SUBMITTALS

- A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.
- B. Manufacturer's Instructions: Special procedures required to install specified products.
- C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.
- D. Manufacturer's Certificate: Products meet or exceed specified requirements.
- E. Qualifications Statements:
 1. Qualifications for manufacturer, and installer.
 2. Manufacturer's approval of installer.
- F. Field quality-control reports.
- G. Project Record Documents: Record actual locations of valves, post-indicators, joints with changes in direction, hydrants, pipe and elevations.
- H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

- B. Perform Work according to Construction Drawings, Cape Fear Public Utility Authority and Owner standards.
- C. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect pipe, pipe fittings, and seals from dirt and damage.
- B. Store according to manufacturer's instructions.
- C. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

1.8 PROJECT CONDITIONS

- A. Interruption of any existing Water Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Owner's Representative no fewer than (72) hours in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Owner's Representative's written permission
- B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 PLASTIC PIPE AND FITTINGS

- A. HDPE Pipe shall be 2 inch minimum, SDR 9, and rated for 200 psi working pressure.
- B. PVC Pipe sized 2 inches shall be per ASTM D2241, IPS, Gasketed Pipe, SDR 21 minimum and shall bear the seal of NSF.
- C. PVC Pipe sizes 4 inches through 12 inches shall conform to AWWA C900 Class 150 (DR 18). Pipe shall bear the seal of NSF. Joints shall conform to ASTM D3139 or ASTM D3212.

2.2 DUCTILE IRON PIPE AND FITTINGS

- A. Ductile iron pipe shall conform to ANSI/AWWA C150/A21.50, ANSI/AWWA C151/A21.51, thickness class 52.
- B. DIP shall have a minimum pressure rating of 350 psi, with asphalt coating and cement mortar lining unless otherwise shown or specified.

- C. Joints shall be push-on or mechanical joints conforming to ANSI/AWWA C111/A21.11, with a minimum pressure rating of 350 psi, with a minimum safety factor of 2:1.
- D. Linings for pipe and fittings shall be standard thickness cement-mortar in accordance with ANSI/AWWA C104/A21.4.
- E. Outside coating shall be a minimum of 1 mil bituminous paint according to ANSI/AWWA C151/A21.51.

2.3 FITTINGS AND SPECIALS

- A. Fittings and specials shall be Thickness Class 52 ductile iron, mechanical joint in accordance with ANSI/AWWA C111/A21.11, ANSI/AWWA C153/A21.53, 150 pounds per square inch pressure rating unless otherwise specified, except that the profile of the bell may have special dimensions as required by the pipe manufacturer with elastomeric gaskets. Ductile iron fittings and specials shall be cement-mortar lined (standard thickness) in accordance with ANSI/AWWA C104/A21.4. Fittings shall be for bell and spigot pipe.
- B. Buried service fittings and specials shall be suitable for 350 psi working pressure. Fittings and specials for mechanical joint pipe shall conform to C153/A21.53.
- C. Above ground service fittings (valve vaults, valve pits, etc.) shall be rated for 250 psi working pressure.

2.4 HYDRANTS

- A. Hydrants shall be iron body, fully bronze mounted, dry barrel type with breakaway flange and stem coupling conforming to AWWA C502.
- B. Hydrant to have a valve opening not less than 4-1/2 inches in diameter.
- C. Hydrant shall have a 6-inch mechanical joint connection on the inlet end.
- D. Outlets shall have one 5 inch STORZ connection and two 2-1/2 inch American National Standard fire hose coupling threads.
- E. All working parts shall be bronze.
- F. Hydrant shall be a Mueller, American Darlings, Clow or approved equal.

2.5 VALVES

- A. Valves shall be iron body, bronze mounted, double disc, parallel seat type meeting the full requirements of AWWA C500, or resilient valves in conformance with AWWA C509 or C515.
- B. Valve shall have a 2-inch operating nut, open left and shall have O-ring seals.
- C. Valve ends shall be mechanical joint, unless otherwise shown or specified.
- D. The valve bonnet shall have 316 stainless steel fasteners.

- E. Valve coating shall conform to AWWA C550 and ANSI/NSF 61.
- F. Valve shall be a Mueller, American Darling, Clow or approved equal.

2.6 INDICATOR POSTS

- A. Indicator posts shall be UL 789, FM-approved, vertical type with cast-iron body and operating wrench, contain an extension rod and an adjustable cast-iron barrel of length required for depth of bury of valve.

2.7 PROTECTIVE ENCLOSURES

- A. Square nut valve boxes shall be cast iron screw adjustment type with flared base. The word "WATER" shall be cast into the cover.
- B. The valve box shall be of such length as will be adapted, without full extension, to the depth of cover required over the pipe at the valve locations.
- C. Boxes shall be installed over each gate valve, and shall conform to ASTM A48 "Grey Iron Castings" Class 30B or approved equal.
- D. Valve boxes in unpaved areas shall be installed with either a pre-cast or poured in place concrete collar.

2.8 SERVICE CONNECTION PIPE AND FITTINGS

- A. Service line shall be in accordance with Construction Drawings, CFPUA and Owner requirements.
- B. Service line shall be 2-inch Polyethylene (PE) tubing, SDR 9, 200 psi working pressure rating, conforming to ASTM D2737/AWWA C901.
- C. Corporation stops shall be a ball valve type, have a 300 psig working pressure and in conformance with AWWA/ANSI C800. Stop to be installed perpendicular to main.
- D. Service saddles for PVC mains shall be wide band, 2 piece brass body. Saddle shall be McDonald 3801 Series, Ford S90 (double strap), Mueller Series H-13000 bronze body or approved equal. No three piece service saddles are permitted.
- E. Service tapping valve shall be a 2 inch Resilient Wedge Gate Valve.
- F. Service valve to be provided with a valve box in accordance with 2.7 Protective Enclosures.

2.9 PIPE LOCATION WIRE

- A. Pipe locator wire shall be installed on all main lines, hydrant legs and services.
- B. Locator wire to be a 10 gauge insulated copper wire rated for underground waterproof application.
- C. Splices in the wire shall be made with an underground rated, watertight splice connector.

2.10 TAPPING SLEEVE AND VALVES

- A. Service taps shall be per CFPUA standard specifications, Section 02660, "Water Distribution System".
- B. Sleeve shall be cast iron or stainless steel 150 psi working pressure, mechanical joint.
- C. Valves shall be open right vertical type with "O" rings seals, mechanical joint outlet end and flange end for connection to tapping sleeve and furnished with a valve box.
- D. Flange end shall have machined projections to ensure correct alignment.
- E. Seat opening of valve shall be slightly larger than nominal size to provide for full diameter cut to be made.
- F. Sleeve shall be furnished by valve manufacturer.

2.11 BACKFLOW PREVENTERS

- A. The CFPUA Cross Connection and Backflow Prevention Ordinance lists the types of backflow prevention assemblies required for different applications.
- B. General: Manufactured backflow preventers, of size indicated for maximum flow rate and pressure loss indicated as allowed.
- C. Working pressure: 150 psig (1035 kPa) minimum, unless otherwise indicated.
- D. 2-inch NPS (DN50) and smaller: Bronze body with threaded ends.
- E. 2-1/2-Inch NPS (DN65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.
- F. Interior Lining: AWWA C550, epoxy coating for backflow preventers with cast-iron or steel body.
- G. Interior Components: Corrosion-resistant materials.
- H. Strainer on inlet if strainer is indicated.
- I. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.
- J. Reduced-Pressure Detector Assembly Backflow Preventers: ASSE 1047, FM approved or UL listed, with OS&Y gate valves on inlet and outlet, and strainer on inlet. Include pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between 2 positive-seating check valves, test cocks, and bypass with displacement-type water meter, valves, and reduced-pressure backflow preventer, for continuous-pressure application.
- K. Pressure Loss: 12 psig (83 kPa) maximum through middle third of flow range.

2.12 PROTECTIVE BACKFLOW ENCLOSURES

- A. Description: Manufactured, weather-resistant and freeze-proof enclosure, meeting ASSE 1060 standards, and designed to protect aboveground water piping equipment or specialties. Include size and dimensions indicated, but not less than those required for access and service of protected unit and the following:
1. Housing: Reinforced-fiberglass construction.
 2. Drain opening for units with drain connection.
 3. Access doors with locking devices.
 4. Insulation inside housing.
 5. Electric heating cable or heater with self-limiting temperature control.
 6. Precast or cast-in-place concrete base of dimensions required to extend at least 6 inches (150 mm) beyond edges of housing.
 7. Anchoring devices to attach housing to base.

2.13 BLOW-OFF ASSEMBLY

- A. Device is used for manual operation of periodic discharge of the waterline at the termination point. Assembly shall be installed in conformance with CFPWA "2" Blow-Off" Detail Standard.

PART 3 EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Division 31 Section "Trenching."

3.2 EXAMINATION

- A. Verify that excavations, dimensions and elevations are as indicated.
- B. Check pipes for cracks or other compromising features.
1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

- A. Correct over-excavation with coarse aggregate.

3.4 PIPING INSTALLATION

- A. Install pipe in strict conformance with AWWA C600. Install plastic pipe in conformance with ASTM D2774 and recommended practices of the UNI-BELL Plastic Pipe Association.

3.5 CUTTING OF PIPE

- A. Cut pipe in a neat and workmanlike manner without damage to the pipe or its lining.

3.6 JOINT DEFLECTION

- A. Maximum joint deflections shall meet the requirements of AWWA C600 or AWWA Manual of Practice M23.

3.7 JOINTING OF PIPE

- A. Precautions shall be taken to protect pipe interiors, fittings and valves against contamination. Pipe delivered for construction shall be strung so as to minimize entrance of foreign material.
- B. When pipe laying is not in progress all openings in the pipeline shall be closed by water-tight plugs. Joints of all pipe in trench shall be completed before work is stopped.
- C. Install all pipe and pipe joints in accordance with AWWA C600 and as manufacturer recommends.

3.8 SETTING OF VALVES AND VALVE BOXES

- A. Install where shown or directed and set plumb on a brick foundation. Valve boxes shall be centered on the valves. Boxes shall be installed over each outside gate valve. Where feasible, valves shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face if less than 4 feet.
- B. Valves after delivery shall be drained to prevent freezing and shall have the interiors cleaned of all foreign matter before installation. Valves shall be fully opened and fully closed to insure that all parts are in working condition.

3.9 FIRE HYDRANT INSTALLATION

- A. Locate and install as shown on the drawings. Each hydrant shall be connected to the main with a 6-inch branch line.
- B. Hydrants shall be set plumb with the pumper nozzle facing the roadway and with the center of the lowest outlet not less than 18 inches above the finished surrounding grade and the operating nut not more than 48 inches above the finished surrounding grade.
- C. The hydrant shall be set in a bed of crushed rock which shall surround the barrel at least 12 inches in all directions.
- D. Hydrants shall be restrained with 316 stainless steel tie rods extending from the main line tee to the hydrant, or by combination of tie rods and blocking or by "Megalug" retainer glands at each joint per manufacturer's requirements.
- E. Hydrant valves shall be located at the main as close to the tee or tap as possible, 18" maximum.

3.10 RESTRAINING AND BLOCKING

- A. The plugs, caps, tees and bends deflecting 11 1/4 degrees or more either vertically or horizontally on water lines 6 inches in diameter or larger shall be provided with thrust blocking or "Megalug" or Camlok retainer gland at each joint, installed per manufacturer's requirements.
- B. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust blocks shall be poured directly against undisturbed earth, with a blocking cure time of 5 days. The sides of thrust blocks not subject to thrust may be poured against forms.
- C. The area of bearing shall be as shown on the plans or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Rods and clamps shall be 316 stainless steel.

3.11 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to plumbing and health department authorities having jurisdiction.
- B. Do not install reduced-pressure-principle type in pit. Use above ground enclosure appropriately sized.
- C. Do not install bypass around backflow preventer.
- D. Support backflow preventers, valves, and piping on brick or concrete piers.
- E. Install tamper switches.
- F. Assembly shall be installed at least twelve inches above the finished grade, flood level, or floor with a maximum height elevation of sixty inches.
- G. There shall be twelve inches clearances on all sides of the assembly.
- H. Electrical equipment, outlets and breaker boxes shall not be located beneath the assembly.
- I. Assembly shall be approved by the USC Foundation for Cross Connection Control or ASSE.

PART 4 FIELD QUALITY CONTROL

4.1 HYDROSTATIC TESTING

- A. Testing shall be in accordance with all CFPWA Standards and Specifications.
- B. After all piping and appurtenances are installed and where any section of a water line is provided with a concrete thrust blocking, the hydrostatic test shall not be made until at least 5 days after installation of the concrete thrust blocking unless otherwise approved.

- C. The method proposed for disposal of wastewater from hydrostatic tests and disinfection shall be submitted to the Owner's representative prior to performing hydrostatic tests. Use clean potable water for all testing.
- D. For purposes of testing, working pressure shall be 100 psi and test pressure shall be 150 psi. The pressure gauge must be liquid filled with 2 psi increments maximum and a minimum of 3 feet above grade. No more than 3 psi can be lost during the two hour test and must the gauge must return to 0 when the test is completed.
- E. Pressure test to be in strict conformance with AWWA C600, Section 4.1 and 4.2. Test for leakage in conformance with AWWA C600, Section 4.2 Table 6. Remedy all visible leaks and locate and repair leakage in lines which exceed the specified amounts.
- F. Contractor to coordinate with Owner for scheduling of test. Owner to be present during any testing.

4.2 CLEANING

- A. Cleaning and disinfection of all piping shall be in accordance with AWWA C-651 and all applicable CFPUA specifications, if discrepancies exist the more stringent shall apply.
- B. 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 that authority, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
 - 3. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine. Isolate system or part thereof and allow to stand for 24 hours. A residual of 10 ppm of chlorine shall be produced in all parts of the system at the end of the 24-hour period. All valves, hydrants and accessories shall be open and/or operated.
 - 4. Following allowed standing time, flush system with clean, potable water until chlorine does not remain above normal water levels in water coming from system.
 - 5. Submit water samples in sterile bottles to the testing laboratory. Repeat procedure if biological examination shows evidence of contamination.
- C. Prepare reports for purging and disinfecting activities.
- D. Clean out the water distribution system and leave free from foreign materials or any sort prior to sterilization.

4.3 DISINFECTION

- A. Disinfection shall be per CFPUA standard specifications, Section 02660, "Water Distribution System".

END OF SECTION 33 1 16-12

SECTION 33 31 00 – SANITARY SEWER PIPING

PART 1 GENERAL

1.1 GENERAL NOTES

- A. All sanitary sewerage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Environmental and Natural Resources standards, and supplemented with any applicable Cape Fear Public Utility Authority standards or specifications. If discrepancies exist they should be brought to the Engineer's attention immediately.
- B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 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. Materials, Installation, and Testing shall be in accordance with NCDOT and Cape Fear Public Utility Authority standards and specifications.

1.3 SUMMARY

- A. This section includes gravity-flow, non-pressure sanitary sewerage outside of the building, which includes but is not limited to the following items and appurtenances, shown on drawings and specified in this Section:
 - 1. Piping.
 - 2. Fittings.
 - 3. Couplings.
 - 4. Manholes.
 - 5. Cleanouts.
- B. Related Sections: The following Sections contain requirements that relate to the Section:
 - 1. Division 31, Section "Trenching"
 - 2. Division 31, Section "Dewatering"

1.4 DEFINITIONS

- A. PVC: Polyvinyl Chloride Pipe.

- B. DIP: Ductile Iron Pipe.
- C. NCDENR: North Carolina Department of Environment and Natural Resources.
- D. CFPUA: Cape Fear Public Utility Authority.

1.5 SUBMITTALS

- A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.
- B. Manufacturer's Instructions: Special procedures required to install specified products.
- C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.
- D. Manufacturer's Certificate: Products meet or exceed specified requirements.
- E. Qualifications Statements:
 - 1. Qualifications for manufacturer, and installer.
 - 2. Manufacturer's approval of installer.
- F. Field quality-control reports.
- G. Project Record Documents: Record actual locations of cleanouts, joints with changes in direction and invert elevations.
- H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

- A. Perform Work according to NCDENR and CFPUA standards and specifications.
- B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store according to manufacturer's instructions.
- B. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.
- C. Handle manholes according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Sewer Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after

arranging to provide temporary service according to requirements indicated:

1. Notify Owner's Representative no fewer than (72) hours in advance of proposed interruption of service.
 2. Do not proceed with interruption of service without Owner's Representative's written permission.
- B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. Sewer mains and service laterals shall have a minimum of 3 feet of cover.
- B. Pipe sizes 4" to 6" shall be SCH 40 conforming to the requirements of ASTM D1785 with solvent weld joints conforming to ASTM D2672.
- C. Pipe sizes 8" through 12" shall be Class 150, DR18 conforming to the requirements of AWWA C900 with elastomeric push-on joints conforming to ASTM D3212 or ASTM D3139.
- D. Couplings shall be mechanical joint ductile iron.
- E. Fasteners shall be 316 stainless steel or better where exposed to sewer or sewer gases.

2.2 DIP AND FITTINGS

- A. Ductile Iron Pipe shall conform to ASTM A746, ANSI/AWWA C151/A21.51, Class 350, lined with Protecto 401 ceramic epoxy, "Sewpercoat" or approved equal unless otherwise shown or specified.
- B. Joints shall be rubber gasket push-on, conforming to ANSI/AWWA C111/A21.11, or mechanical joint conforming to ANSI/AWWA C110/A21.10 as modified by ANSI/AWWA C151/A21.51.
- C. Fittings and specials shall be suitable for 150 pounds per square inch pressure rating unless otherwise specified. Fittings and specials for mechanical joint pipe shall conform to ANSI/AWWA C110/A21.11 lined with Protecto 401 ceramic epoxy, "Sewpercoat" or approved equal unless otherwise shown or specified.

2.3 PIPE COUPLINGS

- A. Couplings between dissimilar pipe materials (PVC to ductile iron) shall be mechanical joint ductile iron only or adapter conforming to ASTM 3139 lined with Protecto 401 ceramic epoxy, "Sewpercoat" or approved equal. For pipes 8" and larger, manholes are also acceptable. Fernco flexible type couplings are NOT permitting.

2.4 MANHOLES

- A. Pipe to manhole connectors shall conform to ASTM C923. The location of the pipe connectors shall vary from the location shown on the project plans no more than ½ inch vertically and 5 degrees horizontally. Provide for control of the pipe OD to within the tolerances of the connector on flexible pipes larger than 12 inches.
- B. Manhole interiors that are required to be lined shall be in accordance with CFPUA standards and specifications.
- C. All in place penetrations into manholes must be by core boring methods including main line and service drops. Properly sized elastomeric boots shall be set in penetrations. The boot and the pipe must be fully mortared on the inside and the outside of the manhole.
- D. Inside drop for sewer mains and services shall conform to the detail with all material to be 316 stainless steel or better, excluding piping. Drop pipe Rev 1.04 02731.6 shall be anchored to the manhole as shown on the detail with intermediate supports on 30-inch spacing as required.
- E. Castings shall be in accordance with CFPUA standards and specifications.

2.5 CLEANOUTS

- A. Cleanout to be nominal 6" diameter by 12" cast-iron box and cover shall be furnished and installed flush with the final grade as per the standard detail shown on the construction drawings.
- B. "C.O." shall be stamped on the lid.
- C. The box shall conform to the standard detail.
- D. Any other required accessories for installation shall be engineer approved prior to installation.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that excavations, dimensions and elevations are as indicated.
- B. Check structures for cracks or other compromising features.
 - 1. Any irregularities shall be reported and approved prior to installation.

3.2 PREPARATION

- A. Correct over-excavation with coarse aggregate.
- B. Prepare base in accordance with applicable CFPUA standard.

3.3 INSTALLATION

- A. Installation Standards: Install Work according to CFPUA standards and manufacturer recommendations. If discrepancies exist they should be brought to Engineer's attention immediately.
- B. Pipe Installation
 - 1. Install PVC pipe in strict accordance with ASTM D2321. Install manholes as indicated on the construction drawings. Install ductile iron pipe in accordance with AWWA C600.
 - 2. Pipe shall be kept clean at all times, and no pipe shall be used in the work that does not conform to the appropriate ASTM Specifications. The laying of pipe in finished trenches shall commence at the lowest point, with the spigot ends pointing in the direction of flow. All pipe shall be laid with the ends abutting accurately to the lines and grades as shown on the plans, or as directed by the Owner. They shall be carefully centered so that when laid they will form a sewer with uniform invert.
 - 3. Preparatory to making pipe joints, all surfaces of the portion of the pipe to be jointed or of the factory made jointing material shall be clean and dry. Lubricants, primers, adhesives, etc. shall be used as recommended by the pipe or joint manufacturer's specifications. The jointing material or factory fabricated joints shall then be placed, fitted, and adjusted in such workmanlike manner as to obtain the degrees of water tightness required. Trenches shall be kept dry during bedding, laying and jointing and for as long a period as required. As soon as possible after the joint is made, sufficient backfill material shall be placed along each side of the pipe to offset conditions that might tend to move the pipe offline and grade.
 - 4. No superficial loads shall be placed on the exposed surface of the trench, unless the backfill is of non-cohesive material, is vibrated or tamped in layers not exceeding 6 inches in depth, until the Owner is satisfied that sufficient settlement has occurred to alleviate undue live or impact loads. Any defects due to settlement shall be corrected by the Contractor at no additional cost to Owner. Bell holes shall be dug sufficiently large to insure the making of proper joints. Water shall not be allowed to rise in the excavation until all the joint material has received its set. Great care shall be used to secure water tightness, and to prevent damage to or disturbing of the joints during the backfilling process or at any other time. Special precautions shall be exercised to prevent any pipe from resting on rock or any other hard projection which might cause breaking of the pipe. During construction, the mouth of the completed pipe shall always be kept properly closed with a suitable plug to prevent the entrance therein of any water, earth, stones or other debris. The Contractor shall also take any and all measures to keep the pipe clean and free from deposits and protect the pipe from damage.

5. Cleaning Pipe: The pipes shall be thoroughly cleaned before they are laid and shall be kept clean until acceptance of the completed work. The upper end of all pipe lines shall be provided with a header carefully fitted, so as to keep dirt and other substances from entering. This header shall be kept in the end of the pipe line at all times when laying is not in actual progress.
6. Service Connections: Sewer laterals shall be connected to the main by means of a wye fitting installed in the top quadrant of the pipe but shall not be installed straight up. Where it is necessary to lay new services or relay or tie in existing services the Contractor shall use the materials and type joints as shown on the plans, as given in the specifications, or as directed by Engineer.
 - a. Services shall be connected at manholes when noted on the drawings or when requested by Engineer. Connections shall be made by core boring manhole and field installation of the proper size elastomeric boot mortared inside and outside the manhole.
 - b. Service lines that enter manholes shall enter on the shelf or at a minimum of crown to crown for the receiving pipe.
7. Contractor to provide a clean-out and stub solvent weld cap as shown in details. During installation, any services, utilities, pavement, concrete etc. damaged by the Contractor shall be properly maintained and repaired to match existing condition by the Contractor at his expense.
8. Clean-outs: Shall be located as per the standard detail. A 6-inch diameter cast box and cover shall be provided over clean-out plug. Clean-out box to be placed on 4 inches of stone.
 - a. Install cleanouts and riser extensions from sewer pipes to clean-outs at grade.
 - b. Use PVC fittings in sewer pipes at branches for cleanouts and PVC pipe for riser extensions to clean-outs.
 - c. Install piping so clean-outs open in direction of flow.
 - d. Use light-duty, top-loading classification clean-outs in earth or unpaved foot-traffic areas.
 - e. Use heavy-duty, top loading classification cleanouts in vehicle traffic service areas.
 - f. Clean-outs frames and covers located in earth shall be in cast-in-place concrete block, 18 inches by 18 inches by 12 inches deep. Set with top 1 inch above surrounding grade.
 - g. Clean-out frames and covers located in pavement shall be set with tops flush to finished pavement surface.
9. Pavements Replacements: Where it is necessary for the Contractor to cut, drop or otherwise remove pavement to install sewer lines, the Contractor shall replace pavement to match existing conditions.
10. Cutting of Pipe: Cut pipe in a neat manner without damage to the pipe or any fittings or specials.

11. Crossings: When sewer crosses water mains, it shall be laid to provide a minimum vertical separation of 18 inches between the bottom of the water main pipe and the top of the sewer pipe. The crossing shall be perpendicular so that the sewer joints will be equidistant and at least 10 feet from the crossing in each direction.

C. Manholes – *Not Used*

3.4 FIELD QUALITY CONTROL

- A. Request inspection by Engineer prior to back filling any aggregate.
- B. If inspections indicate that Work does not meet specified requirements, remove Work, replace and request additional inspections.
- C. Provide a signed and sealed as-built survey by a licensed Land Surveyor in North Carolina for all locations, lengths, sizes and inverts of all structures and piping. Land surveyor should also indicate any and all underground utilities encountered during excavation, including elevations tied to local control.

3.5 TESTING

- A. General: The Contractor shall be responsible for providing all equipment necessary for tests of displacement, deflection, and leakage. Tests of deflection and leakage shall be performed by the Contractor and observed by Owner and/or Engineer.
- B. Test for Deflection: Deflection tests may be performed on all sections of flexible pipe.
 - a. Maximum allowable deflection shall be 5 percent at any point.
 - b. Deflection shall be measured with a pin-type mandrel "Go/No Go" gauge. The gauge shall be pulled through the pipe by means of a strong cord or cable.
 - c. Any section of pipe not meeting the 5 percent maximum deflection shall be excavated, backfilled, re-compacted and retested.
- C. Test for Leakage: All segments of completed line may be tested for leakage by low pressure air test, except that the infiltration test may be used as approved by Owner's representative.
 - a. The Contractor shall remedy all visible leaks in pipes, manholes and appurtenances.
 - b. Air Testing: Air testing shall be conducted in the presence of the Owner and conform to the following:
 1. Test pressure shall be 3.5 psi increased by the ground water pressure above the top of the sewer.
 2. Pressure loss from the 3.5 psi shall not exceed 0.5 psi during the required testing time.
 3. Testing time in minutes shall be calculated at $0.625 \times \text{nominal pipe size (inches)}$.

- D. Test results: Certified copies of all test results shall be furnished to the Owner and Engineer within 1 week of test.

END OF SECTION 33 31 00

SECTION 33 41 00 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 GENERAL NOTES

- A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards and supplemented with any applicable New Hanover County standards. If discrepancies exist, they should be brought to the Engineer's attention immediately.
- B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 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. Materials, Installation, and Testing shall be in accordance with NCDOT and New Hanover County standards and specifications.

1.3 SUMMARY

- A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:
 - 1. Pipe and fittings.
 - 2. inlets and outlets.
- B. Related Sections: The following Sections contain requirements that relate to the Section:
 - 1. Division 31, Section "Earth Moving"
 - 2. Division 03, Section "Cast-In-Place Concrete"

1.4 DEFINITIONS

- A. RCP: Reinforced Concrete Pipe.
- B. NCDOT: North Carolina Department of Transportation.

1.5 SUBMITTALS

- A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.
- B. Manufacturer's Instructions: Special procedures required to install specified products.
- C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.
- D. Manufacturer's Certificate: Products meet or exceed specified requirements.
- E. Qualifications Statements:
 - 1. Qualifications for manufacturer, and installer.

2. Manufacturer's approval of installer.

1.6 FIELD QUALITY-CONTROL REPORTS.

- F. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.
- G. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.7 QUALITY ASSURANCE

- A. Perform Work according to State of North Carolina Department of Transportation and the New Hanover County standards.
- B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect pipe, pipe fittings, and seals from dirt and damage.
- B. Store according to manufacturer's instructions.
- C. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 1. Notify Owner's Representative no fewer than (72) hours in advance of proposed interruption of service.
 2. Do not proceed with interruption of service without Owner's Representative's written permission
- B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 CONCRETE PIPE AND FITTINGS

- A. Reinforced-Concrete Pipe and Fittings: ASTM C 76. Pipe and special fittings installed with 10 feet or less cover, but more than 2 feet of cover, over top of pipe shall be Class III, and all other pipe and special fittings shall be Class IV. Basis of acceptance of reinforced concrete pipe shall be the 0.01" crack.
 1. Bell-and-spigot ends and sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.2 PIPE OUTLETS

- A. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
 - 1. Average Size: NSSGA No. R-3, screen opening 2 inches.
 - 2. Average Size: NSSGA No. R-4, screen opening 3 inches.
 - 3. Average Size: NSSGA No. R-5, screen opening 5 inches.
- B. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.
- C. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton average weight armor stone, unless otherwise indicated.

PART 3 EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 EXAMINATION

- A. Verify that excavations, dimensions and elevations are as indicated.
- B. Check pipes for cracks or other compromising features.
 - 1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

- A. Correct over-excavation with coarse aggregate.
- B. Prepare base in accordance with applicable NCDOT standard.

3.4 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of

pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Laser Equipment: Contractor shall utilize laser equipment to insure that piping is installed at elevations and slopes indicated on plans.
- G. Install gravity-flow, non-pressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow.
 - 2. Install piping at invert elevations as specified in the storm drainage table.
 - 3. Install nonreinforced-concrete piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
 - 4. Install reinforced-concrete piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

3.5 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, non-pressure drainage piping according to the following:
 - 1. Join PVC piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
 - 2. Join nonreinforced-concrete piping according to ASTM C 14 and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
 - 3. Join reinforced-concrete piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.

3.6 STORMWATER INLET AND OUTLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Construct riprap of broken stone, as indicated.
- C. Install outlets that spill onto grade, anchored with concrete, where indicated.
- D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- E. Construct energy dissipaters at outlets, as indicated.

3.7 CONNECTIONS

- A. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
 - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove

section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
 - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
 - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 1. Use identification tape or non-detectable warning tape over all underground lines outside building footprint in the backfill approximately 18" to 30" above the service pipe, but a minimum of 10" and a maximum of 24" below finished grade.
 2. Use detectable warning tape over ferrous and nonferrous piping and over edges of underground manholes. Tape all underground lines outside building footprint directly on top of the pipeline and permanently secured to the pipeline at 10' intervals.
 3. Use insulated copper tracer wire or other approved conductor installed adjacent to underground nonmetallic piping and metallic pipe with compression gasket fittings installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall not be less than 10AWG and the insulation type suitable for direct burial. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type "UF" (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 1. Submit separate reports for each system inspection.

2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. : Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
1. Do not enclose, cover, or put into service before inspection and approval.
 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate report for each test.
 5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
 - b. Option: Test plastic piping according to ASTM F 1417.
 - c. Option: Test concrete piping according to ASTM C 924. C. Leaks and loss in test pressure constitute defects that must be repaired.
 - d. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

- A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION 33 41 00

SECTION 33 49 13 - STORM DRAINAGE STRUCTURES

PART 1 GENERAL

1.1 GENERAL NOTES

- A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards and supplemented with any applicable New Hanover County standards. If discrepancies exist, they should be brought to the Engineer's attention immediately.
- B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 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. Materials, Installation, and Testing shall be in accordance with NCDOT and New Hanover County standards and specifications.

1.3 SUMMARY

- A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:
 - 1. Catch Basins.
 - 2. Drop Inlets.
 - 3. Junction Boxes/Manholes.
 - 4. Headwalls.
 - 5. Accessories.
 - 6. Stormwater Structures.
 - 7. Concrete.
- B. Related Sections: The following Sections contain requirements that relate to the Section:
 - 1. Division 31, Section "Earth Moving"
 - 2. Division 03, Section "Cast-In-Place Concrete"

1.4 DEFINITIONS

- A. RCP: Reinforced Concrete Pipe
- B. NCDOT: North Carolina Department of Transportation.

1.5 SUBMITTALS

- A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.
- B. Manufacturer's Instructions: Special procedures required to install specified products.
- C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.
- D. Manufacturer's Certificate: Products meet or exceed specified requirements.
- E. Qualifications Statements:
 - 1. Qualifications for manufacturer, and installer.
 - 2. Manufacturer's approval of installer.
- F. Field quality-control reports.
- G. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.
- H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

- A. Perform Work according to State of North Carolina Department of Transportation and the New Hanover County standards.
- B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store according to manufacturer's instructions.
- B. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.
- C. Handle manholes according to manufacturer's written rigging instructions.
- D. Handle catch basins, drop inlets, and headwalls according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Owner's Representative no fewer than (72) hours in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Owner's Representative's written permission.
- B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 CATCH BASINS

- A. All catch basins to be precast in accordance with the NCDOT standard specifications.
- B. Catch Basins Lids and Frames:
 - 1. Materials: Cast Iron
 - 2. Lid: Shall be in accordance with applicable NCDOT standard detail as noted.
 - 3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.
- C. Connections
 - 1. All connections to be in accordance with the NCDOT standard specifications.

2.2 DROP INLETS

- A. All drop inlets to be precast in accordance with the NCDOT standard specifications.
- B. Drop inlet Lids and Frames
 - 1. Materials: Cast Iron
 - 2. Lid: Shall be in accordance with applicable NCDOT standard specifications.
 - 3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.
- C. Connections
 - 1. All connections to be in accordance with the NCDOT standard specifications.

2.3 JUNCTION BOXES/MANHOLES

A. Materials

1. Reinforced Concrete. To be precast in accordance with the applicable NCDOT standard specifications.

B. Connections

1. Connections to be minimum soil-tight.
2. All connections to be in accordance with NCDOT standard specifications.

C. Lids and Frames:

1. Shall conform to NCDOT standard specifications.

2.4 HEADWALLS

A. Materials

1. Reinforced Concrete in accordance with North Carolina Railroad standards.

B. Connections

1. Connections to be minimum soil-tight.
2. All connections to be in accordance with Standard Specifications and New Hanover County Standards.
3. In Bored and Jacked scenarios, casing and carrier pipe shall be restrained, as to prevent slipping or other movement.

C. Design

1. Design of headwall to be completed by registered Professional Engineer licensed in North Carolina.
2. Contractor to submit shop drawings to Engineer and Owner for approval. Engineer to only approve shop drawings on the basis of dimensions and size. Engineer not responsible for any footing, shoring or structural aspect of headwall.

2.5 ACCESSORIES

A. Geotextile Fabric:

1. Shall conform to AASHTO M288.
2. Shall be Class 1, and non-biodegradable.

- B. Any other required accessories for installation shall be engineer approved prior to installation.

2.6 STORMWATER STRUCTURES

- A. Cast-in-Place Concrete, Stormwater Structures: Construct of reinforced-concrete bottom, walls, and top; according to ASTM C 890 structural loading; of depth, shape, dimensions, and appurtenances indicated.
 - 1. Anti-Floatation Block: Can either be cast-in-place or precast
 - a. If cast-in-place prior to constructing, the contractor shall insure the weight of the entire riser structures meets minimum specifications provided on Drawings, and shall submit shop drawings to the Engineer for review denoting the following:
 - 1) Steel reinforcement
 - 2) Connection mechanism to join anti-floatation block with riser section.
 - b. If precast, the anti-floatation block shall be included as part of the precast riser shop drawing submittals to the Engineer for review. It shall meet minimum specifications provided on Drawings.
 - 2. Concrete Collar: Shall connect to riser structure and anti-floatation block to form a watertight connection between outlet barrel and riser structure. It shall meet minimum specifications provided on Drawings.
- B. Steps: Provide steps as shown on the Drawings in manholes, risers, transition cones, and transition top sections in accordance with NCDOT STD 840.66. Steps shall be spaced at 16" O.C.
- C. Emergency drawdown pipe shall be a M&H style 1820 eccentric valve or approved equal. This valve is in accordance with AWWA C-540 Sec 5.5, and shall be operable from top of outlet structure via a handwheel. Refer to valve specifications at the end of this section.
- D. Trash rack: Prior to ordering, the contractor shall submit trash rack shop drawings to the Engineer for review. A minimum 2 foot x 3 foot access hatch opening is required and shall be centered over access steps. Trash rack shall meet minimum specifications provided on Drawings.
- E. Spillway Filter: Refer to installation procedures specified in Section 3.3.B.
 - 1. Stone to be fine aggregate, natural, or manufactured sand meeting the requirements of ASTM C33.
 - 2. Collector Pipe shall be smooth wall, schedule 80 PVC, 4-inch nominal diameter with minimum 0.25-inch diameter perforations.
 - 3. Cleanout and Outlet Pipes shall be smooth wall, schedule 80 PVC, 4-inch nominal diameter, solid.

4. Provide elbows, connections, fittings, etc. for piping as required furnished by pipe manufacturer for type of pipe used.
- F. Energy Dissipaters: Refer to Drawings for shape and sizing; Design in accordance with NC Erosion and Sediment Control Planning and Design Manual.

2.7 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:
 1. Cement: ASTM C 150, Type II.
 2. Fine Aggregate: ASTM C 33, sand.
 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
 1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - a. Invert Slope: 2 percent through manhole.
 2. Benches: Concrete, sloped to drain into channel.
 - a. Slope: 50 percent.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

PART 3 EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.1 EXAMINATION

- A. Verify that excavations, dimensions and elevations are as indicated.
- B. Check structures for cracks or other compromising features.
 - 1. Any irregularities shall be reported and approved prior to installation.

3.2 PREPARATION

- A. Correct over-excavation with coarse aggregate.
- B. Prepare base in accordance with applicable NCDOT standard.

3.3 INSTALLATION

- A. Installation Standards: Install Work according to NCDOT standards and manufacturer recommendations. If discrepancies exist, they should be brought to Engineer's attention immediately.
- B. Spillway Filter Installation
 - 1. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system. Trench shall extend at least 2 feet below spillway pipe.
 - 2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
 - 3. Place supporting layer of drainage course (NCDOT #67 washed stone) as specified on Drawings.
 - 4. Install perforated piping as specified on Drawings for spillway filter subdrainage.
 - 5. Contractor shall provide a watertight seal between the filter fabric and principal spillway pipe.
 - 6. Add drainage course (NCDOT #67 stone) to top of drainage conduits. Spillway filter depth shall be in accordance with the depth specified in the Drawings. Cover drainage conduit as specified on Drawings.
 - 7. Completely overlap both sides of filter fabric above drainage course. Top of overlap shall correspond to seepage direction.
 - 8. Fill to Grade: Fill with satisfactory soil to finish grade. Fill above the filter fabric shall consist of well-compacted clayey soils to prevent down slope run-off from rainfall from entering the drain.

9. Care shall be taken during the drain construction to keep the washed stone clean and free of soil contamination; otherwise, the effectiveness of the drain can be seriously jeopardized.

3.4 FIELD QUALITY CONTROL

- A. Request inspection by Engineer prior to back filling any aggregate.
- B. If inspections indicate that Work does not meet specified requirements, remove Work, replace and request additional inspections.
- C. Provide a signed and sealed as-built survey by a licensed Land Surveyor in North Carolina for all locations, lengths, sizes and inverts of all storm drainage structures and piping. Land surveyor should also indicate any and all underground utilities encountered during excavation, including elevations tied to local control.

3.5 CLEANING

- A. Clean interior of structures of dirt and superfluous materials. Flush with water.

END OF SECTION 33 49 13