ARCHITECTS
Capital Bank Plaza
333 Fayetteville Street, Suite 225
Raleigh NC 27601

PROJECT MANUAL

VOLUME 3 of 3

Divisions 20 thru 39

Harnett County Schools
1008 South 11th Street
Lillington, North Carolina 27546

Multiple Schools - Additions / Renovations

Architect's Project Number: 02110.000

Locations:

Highland Elementary School
1915 Buffalo Lake Road
Sanford, NC 27332

Overhills Elementary School
2626 Ray Road
Spring Lake, NC 28390

Harnett Primary School
800 W Harnett Street
Dunn, NC 28334

August 15, 2022
Bid Set

Set Number: ____________

SECTION 00 01 01

PROJECT TITLE PAGE

Date	August 15, 2022 Bid Set
Project Identification	Multiple Schools - Additions / Renovations Architect's Project Number: 02110.000 Locations: Highland Elementary School 1915 Buffalo Lake Road Sanford, NC 27332 Overhills Elementary School 2626 Ray Road Spring Lake, NC 28390 Harnett Primary School 800 W Harnett Street Dunn, NC 28334
Owner	Harnett County Schools 1008 South 11th Street Lillington, North Carolina 27546 Telephone: 910-893-8151
Architect	SfL+a Architects 333 Fayetteville Street, Suite 225 Raleigh, North Carolina 27601 Telephone: 919-573-6350
Structural Engineer	LHC Structural Engineers 5430 Wade Park Blvd, Suite 400 Raleigh, North Carolina 27607 Telephone: 919-832-5587
Fire Protection Engineer **Plumbing Engineer** **Mechanical Engineer** **Electrical Engineer**	Optima Engineering, PA 150 Fayetteville Street, Suite 520 Raleigh, North Carolina 27601 Telephone: 919-926-2200

Civil Engineer	LKC Engineering, PLLC 140 Aqua Shed Court Aberdeen, NC 28315 Telephone: 910-420-1437

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NC Registration Number 50676

Architectural

SfL+a Architects, PA
Thomas Warren Hughes
NC Registration Number 9537

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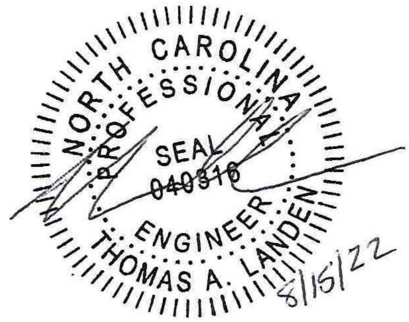
LHC Structural Engineers, A Division of Bennett & Pless
Robert E. Lasater, Jr.
NC Registration Number 14526

Fire Protection Engineering
Plumbing Engineering

Optima Engineering, PA
Gary P. Kosten
NC Registration Number 032219

Mechanical Engineering

Optima Engineering, PA
Thomas A. Landen
NC Registration Number 040316



Electrical Engineering
Fire Alarm Engineering

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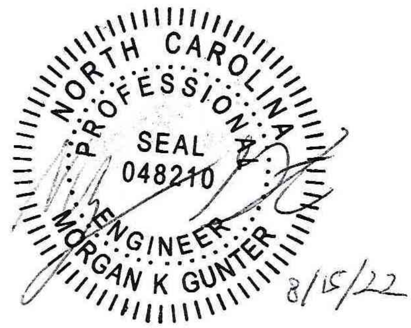
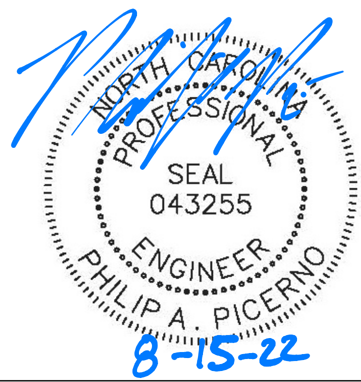


Civil Engineering

LKC Engineering, PLLC
Philip A. Picerno
NC Registration Number 043255



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_OES = Overhills Elementary School
_HPS = Harnett Primary School
_HES-HPS = Highland Elementary School & Harnett Primary School
_HES-OES = Highland Elementary School & Overhills Elementary School

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FIRE PROTECTION GENERAL REQUIREMENTS

PART 1 GENERAL

1.1 STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. The general conditions shall be carefully examined before proposals for any work are submitted. Division twenty-one shall not be interpreted as waiving or overruling any requirements expressed in the general conditions unless division twenty-one specifications contain statements more definitive or more restrictive.

C. Nothing herein contained shall be so construed as to relieve the contractor from performing their work according to the true intent and meaning of the contract drawings and specifications. The contractor will be held responsible to provide all materials and equipment and shall provide all labor necessary for the complete, prompt, and satisfactory execution of the work. The contractor is also responsible for the proper coordination of their work with all other trades.

D. The contractor shall bear all expenses incidental to the satisfactory completion of the work contained in the contract drawings and specifications.

1.2 DEFINITIONS

A. Where words and phrases used throughout the contract documents are not specifically defined in the reference standards, they shall be interpreted by the meanings given to them in the latest edition of the Merriam-Webster dictionary.

B. Words and phrases used throughout the contract documents shall be interpreted as indicated below:

1. 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 fire protection construction work.
2. Others: A person or organization other than the contractor, owner, or professional.
3. Owner: The person or organization that awards the construction contract, or their designated representative.
4. Professional: The engineer of record.
5. Provide: To furnish and install materials, equipment, or systems.
6. Submittals: Industry standards, manufacturer’s data, manufacturer’s warranties, operation and maintenance instructions, shop drawings, and test reports.
7. Work: All labor, materials, equipment, and services necessary and reasonably incidental to the proper completion and proper operation of the fire protection systems.

1.3 REFERENCES

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.

B. The publications listed below form a part of this specification. All publications shall be the latest edition as adopted by the authority having jurisdiction at the date of bid advertisement. The minimum standard of work under this contract shall be in accordance with the following model building codes or standards:

1. International Building Code (IBC) with North Carolina Amendments:
    a. North Carolina Building Code.
    b. North Carolina Fire Prevention Code.
    c. North Carolina Mechanical Code.
    d. North Carolina Plumbing Code.
2. National Fire Protection Association:
    a. NFPA 13 – Standard for the Installation of Sprinkler Systems.
    b. NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection.
    c. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
    d. NFPA 70 – National Electric Code.
    e. NFPA 72 – National Fire Alarm and Signaling Code.

1.4 SCOPE

A. Wet-pipe sprinkler systems: The wet-pipe sprinkler systems shall be extended to all equipment and accessories, including those provided by others as determined in the construction contract. For systems with piping outside of the building, the wet-pipe sprinkler systems shall be extended from a point twelve (12) inches above the finish floor. Final connection at the point of utility installation shall be made by the contractor.

1.5 RELATED WORK

A. The contractor shall obtain all licenses, permits, etc. and shall pay all associated connection fees, tapping fees, inspection fees, etc. These costs shall be included in the contract price.

B. 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 by others as indicated below:

1. General contractor:
    a. Installation of access panels.
    b. Concrete housekeeping and structural pads for equipment.
    c. Cutting and patching: The general contractor shall perform cutting and patching of floors, roofs, and exterior walls when necessary for the installation of the work.
    d. The general contractor shall provide final painting of walls, floors, and ceilings where the surfaces are being provided, refinished, or remodeled under the general contract. The general contractor shall perform all required painting of piping provided by the contractor.
2. Fire alarm contractor:
    a. Connection of all pipeline installed alarm devices to the building fire alarm system.
    b. Installation of all supervisory signal devices for pipeline installed accessories and connection of these devices to the building fire alarm system.
3. Electrical contractor:
    a. Verification of the proper rotation of three-phase equipment, and any modifications required to correct improper rotation.
    b. Installation of all combination starters/disconnects and overload protectors.

c. Installation of all line side wiring and junction boxes and/or receptacles supplying fire protection equipment.

1.6 QUALITY ASSURANCE

A. The contractor shall become thoroughly familiarized with all specifications and drawings for the project so that they clearly understand their responsibility in relationship to the work to be performed. The contractor shall plan and perform their work so as to permit the use of the building at the earliest possible date.

B. Changes from the contract documents 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.

C. The contractor is responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the contract documents.

D. The contractor shall expressly and completely follow the manufacturer's 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 guarantee all work, materials, and equipment furnished against defects, leaks, performance, and non-operation for a period of one (1) year after the date of the owner's final acceptance, or as indicated in the general conditions. Defects shall be interpreted as defective materials or equipment or unsatisfactory installation and are not intended to apply to ordinary wear and tear. The contractor shall pay for any repairs or replacements caused by these defects within the period covered by the guarantee, including all incidental work required to fix the deficiency.

1.7 MATERIALS

A. Any device that has the physical appearance of life safety or fire protection equipment but that does not perform that life safety or fire protection function shall be prohibited.

B. Provide products requiring electrical connections listed and labeled by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.8 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. The contractor is responsible for the correctness of this information.

B. Any difference identified by the contractor shall be submitted to the professional for consideration before proceeding with the work.

C. No extra compensation will be considered based on differences between actual dimensions and measurements and those indicated on the drawings.

1.9 PROTECTION OF UTILITIES

A. All existing service utilities shall remain active during construction. Any service underground, aboveground, interior, or exterior damaged, broken, or otherwise rendered inoperative during the course of construction due to activities on the part of the contractor shall be properly repaired by the contractor at their own expense. The method used in repairing, replacing, or maintaining the services shall be submitted to the professional for review and approval.

1.10 INTERRUPTION OF UTILITIES

A. The contractor shall schedule their work to avoid interruption of any utility services.

B. Existing utilities serving occupied facilities shall not be interrupted except when such interruptions have been authorized by the owner. Interruptions may occur only after acceptable temporary utility services have been provided. The contractor shall provide a minimum of ten (10) working days' notice to the owner and receive written notice to proceed before interrupting any utility.

1.11 PROTECTION OF WORK

A. At their own expense, the contractor shall protect their work, materials, or equipment that is subject to damage during the project duration. All openings into any piping, ducts, or equipment shall 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 is responsible for all damage until their work is fully and finally accepted.

1.12 CHASES AND OPENINGS

A. All chases and openings required for the installation of the work shall be coordinated with the work of other trades. The contractor shall provide the other trades with sufficient time for coordination of all chases and openings. The contractor shall be responsible for cutting and patching all openings in walls and partitions necessary for the work.

B. The contractor shall provide all sleeves, hangers, and anchors required for installation of the work in chases and openings.

1.13 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 fire protection 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.

1.14 CROSS CONNECTION CONTROL

A. The contractor shall coordinate water service requirements in accordance with the local water utility regulations, including required permits, backflow preventers, meters, piping, valves, bypasses, supports, and other accessories.

B. Where these services are provided by others, the contractor shall verify that they are complete and have been inspected prior to making final connection(s).

1.15 CLEANUP

A. 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 is not permitted.

B. 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, the site and public properties shall be cleaned and waste materials, debris, and rubbish disposed of in an appropriate manner.

C. At the completion of the project, the contractor shall remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed accessories and equipment; remove grease, dust, dirt, stains, labels, fingerprints, and other foreign materials from sight-exposed accessories and equipment; broom clean paved and concrete surfaces; rake clean other ground surfaces; repair, patch, and touch-up marred surfaces to the specified finish or to match adjacent surfaces.

1.16 PROJECT CLOSEOUT DOCUMENTATION

A. The contractor shall keep a record of construction changes and deviations from the original contract documents. All changes shall be recorded on a separate set of prints, which shall be kept at the project 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 utility lines.
   2. Changes in pipe size and routing location.
   3. Valve locations.
   4. Equipment locations.
   5. Actual capacities and values of equipment provided.

B. The marked-up record set of construction documents shall be delivered to the professional after final acceptance of the work.

C. The contractor shall deliver operation and maintenance manuals per section 21 01 05 to the professional before instruction of the owner and after final acceptance of the work.

1.17 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 ten (10) business days' advance notice before the instruction session(s).

PART 2 PRODUCTS

2.1 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, fittings, and all appurtenances.

B. Access panels shall be of sufficient size to permit removal or access, except that the minimum size shall be twelve (12) inches by sixteen (16) inches.

C. Access door locations shall be as determined by field conditions for optimum access to equipment and shall be reviewed by the owner before final installation. Access door locations 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 six (6) inches above floor, whichever is greater.
   2. Tops and/or sides of access panels shall be a minimum of six (6) inches from the ceiling, other openings, or from the edge of a wall.

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 an Underwriter's Laboratory listing shall be provided in fire-resistance-rated construction assemblies. Access doors shall have a fire-resistance rating of no less than that required by the North Carolina Building and Fire Prevention Codes for each assembly in which they are installed. Maximum size shall be twenty (20) inches by twenty (20) inches or four hundred (400) square inches in area. Frame shall be sixteen (16) gauge minimum steel and the panel shall be twenty (20) gauge minimum steel.

G. Access doors without an Underwriter's Laboratory label shall be provided in all non-rated construction assemblies. Frame shall be sixteen (16) gauge minimum steel and the panel shall be fourteen (14) gauge minimum steel.

H. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges, flush-face type lock with key operation, and self-latching cylinder locks.

I. Access doors shall open a minimum of one-hundred-seventy-five (175) degrees.

J. All access doors shall be keyed alike.

PART 3 EXECUTION

3.1 GENERAL

A. The contract documents are diagrammatic and are indicative of the work to be performed. It is not intended that they show every pipe, fitting, offset, change in direction, or appurtenance required for a complete installation.

B. 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 printed instructions.

3.2 INSPECTION AND TESTING

A. Fire detection and alarm systems, fire-extinguishing systems, fire hydrant systems, fire standpipe systems, fire pump systems, private fire service mains and all other fire protection systems and appurtenances thereto shall be subject to acceptance tests as contained in the installation standards and as approved by the fire code official.

B. It is unlawful to occupy any portion of a building or structure until the required fire detection, alarm, and suppression systems have been tested and approved.

C. The fire code official shall be notified before any required acceptance testing.

D. The contractor shall notify the professional a minimum of five (5) working days prior to testing to coordinate the testing and inspection procedures.

E. The contractor shall provide all equipment, material, labor, etc. required for testing the fire protection systems.

F. All new, altered, extended, or replaced fire protection systems shall be left uncovered and unconcealed until they have been inspected, tested, and accepted by the professional and fire code official. Where such work has been covered or concealed before it has been inspected, tested, and accepted, it shall be uncovered by the contractor, at their own expense as directed by the professional or fire code official.

G. If the professional or fire code official determines that the fire suppression systems do not pass the prescribed tests, then the contractor shall be required to make the necessary repairs, at their 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 or fire code official.

H. The contractor shall have all associated NFPA inspection forms prepared and on site at the time of inspection for review and acceptance by the professional or fire code official. No other forms will be accepted. All non-signature form information shall be typed.

I. The contractor shall maintain a readily available copy of all inspection forms on site and shall forward a copy of each form to the owner, professional, and fire code official after testing has been completed.

END OF SECTION

SECTION 21 01 05

FIRE PROTECTION SUBMITTAL REQUIREMENTS

PART 1 GENERAL

1.1 STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. Failure of the contractor to provide a complete submittal package may result in delay in processing time. All such delays to the project resulting from the contractor's failure to provide submittals in a timely fashion will be the responsibility of the contractor.

1.2 DEFINITIONS

A. Industry standard: Printed copies of the current standards recognized in the industry. Current means the latest issue as of the date of these specifications; within the text of these specifications the date suffix frequently shown with identification numbers has been omitted.

B. Manufacturer's data: Product manufacturer's standard printed information, including promotional brochures, product specifications, installation instructions and diagrams, statements of compliance with standard performance charts or curves, and similar information concerning the standard portions of a manufacturer's products.

C. Manufacturer's warranty: Manufacturer's standard printed commitment in reference to a specific product and normal application, stating that certain acts of restitution will be performed for the purchaser or owner by the manufacturer, if and when the product fails within certain operational conditions and time limits.

D. Operation and maintenance instructions: The written instructions by the manufacturer, fabricator, or installer of equipment or systems, detailing the procedures to be followed by the owner in operation, maintenance, control, and shutdown of each operating item of the equipment or system.

E. Shop drawings: Project shop drawings and other data prepared specifically for fulfillment of the project requirements. Shop drawings include fabrication, layout, setting, installation, coordination, and similar drawings and diagrams, and include performance data associate therewith, including weights, capacities, speeds, outputs, consumption, efficiencies, voltages, amperages, cycles, phases, noise levels, operating ranges, and similar information.

F. Test reports: Specific reports prepared by an independent testing laboratory, showing the results of specified testing on either the material or equipment provided or on identical material or equipment.

1.3 SUBSTITUTIONS

A. Submittals are not opportunities for gaining acceptance of substitutions. Where three or more manufacturers are specified by name or by catalog reference, the contractor shall select for use any of those so specified.

B. Should the contractor desire to substitute another manufacturer's equipment for one specified by name, the contractor shall apply in writing at least ten (10) business days prior to bid date for such permission. The contractor shall provide submittal data for the professional's consideration. No substitution shall be made for any material, article, or process under the contract unless approved by the professional.

C. Any time that is required by the professional for a request to review submittals for substitutions after the award of bids will be billed to the contractor at the professional's published hourly billing rate. The professional's review time will be billed to the contractor whether the proposed substitution is accepted or rejected.

1.4 SUBMITTAL FORM AND PROCEDURES

A. Submittals shall be assembled as single file electronic submittals. Transmittals shall be included within the file as the first page.

B. Submittals shall be made in separate packages containing all the required documentation indicated in each specification section. Only one (1) submittal package shall be made for each specification section. Partial submissions will not be addressed.

C. Submittals shall be complete and clearly identified and cross-referenced to the appropriate specification section.

D. The data shown on the submittals shall be complete with respect to dimensions, design criteria, materials of construction, and the like to enable the professional to review the information as required.

E. The contractor shall stamp the submittals and verify by signature that the submittals have been checked for compliance with the contract documents and appropriate means have been taken to ensure that the material or equipment will fit into the space available.

F. At the time of each submission, the contractor shall in writing call the professional's attention to any deviations that the submittal may have from the requirements of the contract documents.

G. The submittals shall be clearly marked indicating which specific options are being considered and with all related information.

H. The professional's review of submittals is for general conformance with design concept only. Corrections or comments made on the submittals during review do not relieve the contractor from compliance with requirements of the contract documents.

I. The contractor is responsible for all quantities, dimensions, and coordination of the work of all trades. The contractor is responsible for selecting fabrication processes and techniques of construction and for performing all work in a safe and satisfactory manner.

J. No work requiring a submittal shall be commenced until the submittal has been reviewed by the professional.

K. A copy of each approved submittal shall be kept in good order by the contractor and shall be made available at the site.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Submit after final approval for review by the professional.

B. The contents of the submittal shall be prepared as follows:
   1. Table of contents.
   2. A directory listing names, addresses, and telephone number of professional, contractor, subcontractors, and equipment suppliers.
   3. Project documents and certificates:
      a. Certificates of compliance.
      b. Photocopies of warranties and bonds.
      c. Material safety data sheets (MSDS).
   4. Operation and maintenance instructions subdivided by specification section. For each item, identify the following:

a. Significant design criteria.
b. Parts list for each component.
c. Maintenance instructions for equipment and systems.
d. Maintenance instructions for finishes including recommended cleaning methods and materials and operating instructions.
e. Special precautions identifying detrimental agents.
f. Special requirements of other sections of this specification noted to be included in the operation and maintenance manual.

C. Submit copies for review by the owner ten (10) business days prior to owner training.

END OF SECTION

SECTION 21 05 32

FIRESTOPPING FOR FIRE PROTECTION SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
   1. Firestopping relating to fire protection work.
   2. Firestopping accessories.

1.2 REFERENCES

A. ASTM International:
   1. ASTM E84 – Test Method for Surface Burning Characteristics of Building Materials.
   2. ASTM E814 – Test Method of Fire Tests of Through Penetration Firestops.

B. Underwriters Laboratories, Inc.:
   1. UL 723 – Tests for Surface Burning Characteristics of Building Materials.
   2. UL 1479 – Fire Tests of Through-Penetration Firestops.

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 SUBMITTALS

A. Refer to specification section 21 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:
   1. Firestopping relating to fire protection work.
   2. Firestopping accessories.

C. Submit a 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. Submit manufacturer's preparation and installation instructions for each listed design number.

1.5 QUALITY ASSURANCE

A. Through-penetration firestopping of fire-rated assemblies: UL 1479, ASTM E814; with one-tenth (0.1) inch water gauge minimum positive pressure differential to achieve fire F-ratings and temperature T-ratings as indicated on life safety drawings, but not less than one (1) hour.

B. Surface burning characteristics: Flame spread index of twenty-five (25) and smoke developed index of fifty (50) when tested in accordance with UL 723 or ASTM E84.

C. Perform work in accordance with the latest edition of the North Carolina Fire Prevention Code and any local codes, ordinances, or construction standards.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Do not apply firestopping materials when temperature of substrate material and ambient air is below sixty (60) degrees Fahrenheit.

B. Maintain this minimum temperature before, during, and for minimum three (3) days after installation of firestopping materials.

C. Provide ventilation in areas to receive solvent-cured materials.

PART 2 PRODUCTS

2.1 FIRESTOPPING

A. 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/elastomeric firestopping: Single component silicone elastomeric compound and compatible silicone sealant.
   2. Foam firestopping compounds: Single 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 fiber stuffing insulation with silicone elastomer for smoke stopping.
   5. Intumescent firestopping: Intumescent putty compound which expands on exposure to surface heat gain.

B. Color: As selected from manufacturer's full range of colors to match adjacent surfaces.

2.2 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.
   2. Select products with rating not less than rating of wall or floor being penetrated.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Verify openings are ready to receive firestopping.

B. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

C. Remove incompatible materials affecting bond.

D. Install backing or damming materials to arrest liquid material leakage.

3.2 INSTALLATION

A. Install material at fire-rated construction perimeters and openings containing penetrating sleeves, piping and other items, requiring firestopping.

B. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.

C. Apply firestopping material in sufficient thickness to achieve required fire and smoke rating to uniform density and texture.

END OF SECTION

SECTION 21 05 48

VIBRATION CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Elastomeric hangers.
5. Snubbers.
6. Restraints - rigid type.
7. Restraints - cable type.
8. Restraint accessories.
9. Post-installed concrete anchors.
10. Concrete inserts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Include load rating for each wind-load-restraint fitting and assembly.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Consequential Damage: Provide additional restraints for suspended fire-suppression system components or anchorage of floor-, roof-, or wall-mounted fire-suppression system components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential fire-suppression system component will not cause the failure of any other essential architectural, mechanical, or electrical building component.

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

C. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
4. Surface Pattern: Smooth, ribbed, or waffle pattern.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil and water resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

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

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

2.5 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.

2.6 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.7 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.8 RESTRAINTS - CABLE TYPE

A. Seismic-Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

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

2.9 RESTRAINT ACCESSORIES

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

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

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

2.10 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-10, Ch. 13.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.11 CONCRETE INSERTS

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

B. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to high wind forces.

C. Strength of Support and Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind load within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL DEVICES

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

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

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

D. Equipment Restraints:

1. Install snubbers on fire-suppression equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

E. Piping Restraints:

1. Comply with all requirements in NFPA 13.
2. Design piping sway bracing according to NFPA 13.

   a. Maximum spacing of all sway bracing to be no greater than indicated in NFPA 13.
   b. Design loading of all sway bracing not to exceed values indicated in NFPA 13.

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

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Post-Installed Concrete 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. Mechanical-Type Anchor Bolts: 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-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL STRUCTURAL MOTION

A. Install flexible connections in piping where they cross structural construction joints and other points where differential movement may occur, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

3.5 ADJUSTING

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.6 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. 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 postconnection 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 no fewer than four of each type and size of installed anchors and fasteners.
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.

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

E. Units will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 210548

SECTION 21 13 00

AUTOMATIC SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Aboveground pipe and tube.
2. Pipe fittings.
3. Valves.
4. Sprinklers.
5. System attachments.
6. Hangers and supports.
7. System signage.

1.2 REFERENCES

A. American Welding Society (AWS):

1. AWS B2.1 – Specification for Welding Procedure and Performance Qualification.

B. ASME International:

1. ASME B1.20.1 – Pipe Threads, General Purpose (Inch).
2. ASME B16.1 – Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
3. ASME B16.3 – Malleable Iron Threaded Fittings: Classes 150 and 300.
4. ASME B16.4 – Gray Iron Threaded Fittings: Classes 125 and 250.
5. ASME B16.5 – Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
6. ASME B16.9 – Factory-Made Wrought Buttwelding Fittings.
7. ASME B16.11 – Forged Fittings, Socket-Welding and Threaded.
8. ASME B16.25 – Buttwelding Ends.
9. ASME Boiler and Pressure Vessel Code, Section IX – Welding and Brazing Qualifications.

C. ASTM International:

1. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A135 – Standard Specification for Electric-Resistance Welded Steel Pipe.
3. ASTM A234 – Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
4. ASTM A795 – Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.

D. International Building Code with North Carolina Amendments:

1. North Carolina Fire Prevention Code.
2. North Carolina Plumbing Code.

E. National Fire Protection Association (NFPA):

1. NFPA 13 – Standard for the Installation of Sprinkler Systems.
2. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
3. NFPA 70 – National Electrical Code.
4. NFPA 72 – National Fire Alarm and Signaling Code.

1.3 SUBMITTALS

A. Refer to specification section 21 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:

1. Aboveground pipe and tube.
2. Pipe fittings.
3. Valves.
4. Sprinklers.
5. System attachments.
6. Hangers and supports.
7. System signage.

C. Submit shop drawings in accordance with the following:

1. Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled.
2. Deviation from approved plans shall require permission of the authority having jurisdiction.
3. Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system:

a. Name of the owner and occupant.
b. Location, including street address.
c. Point of compass.
d. Full height cross section, or schematic diagram, including structural member information if required for clarity and including ceiling construction.
e. Location of partitions.
f. Location of fire walls.
g. Occupancy class of each area or room.
h. Location and size of concealed spaces, closets, attics, and bathrooms.
i. Any small enclosures in which no sprinklers are to be installed.

j. Size of city main in street and whether dead end or circulating; if dead end, direction, and distance to nearest circulating main; and city main test results and system elevation relative to test hydrant.

k. Other sources of water supply, with pressure or elevation.

l. Make, type, model, and nominal K-factor of sprinklers including sprinkler identification number.

m. Temperature rating and location of high-temperature sprinklers.

n. Total area protected by each system on each floor.

o. Number of sprinklers on each riser per floor.

p. Pipe type and schedule of wall thickness.

q. Nominal pipe size and cutting lengths (or center-to-center dimensions). Where typical branch lines prevail, it shall be necessary to size only one typical line.

r. Location and size of riser nipples.

s. Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used.

t. Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable.

u. All control valves, check valves, drainpipes, and test connections.

v. Make, type, model, and size of alarm valve.

w. Kind and location of alarm bells.

x. Private fire service main sizes, lengths, locations, weights, materials, point of connection to city main; the sizes, types, and locations of valves, valve indicators, regulators, meters, and valve pits; and the depth that the top of the pipe is laid below grade.

y. Piping provisions for flushing.

z. For hydraulically designed systems, the information on the hydraulic data nameplate.

aa. A graphic representation of the scale used on all plans.

bb. Name and address of the contractor.

cc. Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets.

dd. The minimum rate of water application (density or flow or discharge pressure), the design area of water application, and the water required for hose streams both inside and outside.

ee. The total quantity of water and the pressure required noted at a common reference point for each system.

ff. Relative elevations of sprinklers, junction points, and supply or reference points.

gg. If room design method is used, all unprotected wall openings throughout the floor protected.

hh. Information about backflow preventers.

ii. Static and residual hydrants that were used in flow tests shall be shown.

jj. Size, location, and piping arrangement of fire department connections.

kk. Ceiling/roof heights and slopes not shown in the full height cross section.

ll. Edition year of NFPA 13 to which the sprinkler system is designed.

4. A signed copy of the owner's certificate and the shop drawing submittal shall include the manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings.

5. Water supply information:

a. Include the following water supply capacity information:

1) Location and elevation of static and residual test gauge with relation to the riser reference point.

2) Flow location.

3) Static pressure in psi.

4) Residual pressure in psi.

5) Flow in gpm.

6) Date.

7) Time.

8) Name of person who conducted the test or supplied the information.

9) Other sources of water supply, with pressure or elevation.

b. Where a waterflow test is used for the purposes of system design, the test shall be conducted no more than twelve (12) months prior to working plan submittal unless otherwise approved by the authority having jurisdiction.

c. The following information shall be included when water supply treatment is provided:

1) Type of condition that requires treatment.

2) Type of treatment needed to address the problem.

3) Details of treatment plan.

D. Submit hydraulic calculations in accordance with the following:

1. Hydraulic calculations shall be prepared on form sheets that include a summary sheet, a graph sheet, a water supply analysis, a node analysis, and detailed worksheets.

2. The data shall be presented in the order shown in NFPA 13.

a. Only the order of information shall be maintained. Standard formats provided by approved calculation software shall be permitted so long as they include all required information listed in each subsequent section.

3. The summary sheet shall contain the following information, where applicable:

a. Project name and date.

b. Location, including street address.

c. Drawing number.

d. Remote area number.

e. Remote area location.

f. Occupancy or commodity classification.

g. System design requirements, as follows:

1) Design area of water application in square feet.

2) Minimum rate of water application in gpm/sf.

3) Area per sprinkler in square feet.

h. Total water requirements as calculated, including allowance for inside hose and outside hydrants in gpm.

i. Type of system.

j. Water supply information, including the following:

1) Date.

2) Location.

3) Source.

4) Elevation relative to finished floor.

k. Name and address of installing contractor.

l. Name of designer.

m. Authority having jurisdiction.

n. Notes that include items such as peaking information for calculations performed by a computer program, limitations (dimension, flow, and pressure) on extended coverage or other listed special sprinklers.

4. A graphic representation of the complete hydraulic calculation shall be plotted on semi-exponential graph paper ($Q^{1.85}$) and shall include the following:

a. Water supply curve.

b. Sprinkler system demand.

c. Hose demand.

d. Additional pressures supplied by a fire pump or other source.

5. Information summarized from the graph sheet shall include the following:

a. Node tag at the source.

b. Static pressure available at the source in psi.

c. Residual pressure available at the source in psi.

d. Total flow available at the source in gpm.

e. Available pressure at the source when the total calculated demand is flowing in psi.

f. Total calculated demand at the source in gpm.

g. Required pressure when flowing total calculated demand in psi.

6. Organized information regarding the node tags given to each hydraulic reference point on the system as indicated on the shop drawings shall include the following information:

   a. Node tag for each specific point on the system used in the hydraulic calculations.

   b. Elevation of each node tag in feet.

   c. K-factor of flowing nodes.

   d. Hose allowance requirements for the node tag in gpm.

   e. Pressure at the node in psi.

   f. Discharge calculated at the node in gpm.

   g. Notes that indicate any special requirements for the node.

7. Detailed worksheets shall contain the following information:

   a. Sheet number.

   b. Hydraulic reference points used in each step.

   c. Elevation at each hydraulic reference point in feet.

   d. Sprinkler description and discharge constant for the flowing reference point.

   e. Flow for the flowing reference point in gpm.

   f. Total flow through each step-in gpm.

   g. Nominal pipe size in inches.

   h. Actual internal diameter of pipe in inches.

   i. Quantity and length of each type of fitting and device in feet.

   j. Pipe lengths from center-to-center of fittings in feet.

   k. Equivalent pipe lengths of fittings and devices for the step-in feet.

   l. Total equivalent length of pipes and fittings for the step-in feet.

   m. C-factor used in each step.

   n. Friction loss of pipe in psi/ft.

   o. Sum of the pressures from the previous step (starting pressure at beginning).

   p. Elevation head between reference points in psi.

   q. Total friction loss between reference points in psi.

   r. Required pressure at each reference point in psi.

   s. Notes and other information shall include the following:

      1) Velocity pressure and normal pressure if included in calculations.

      2) Notes to indicate starting points or reference to other sheets or to clarify data shown.

3) Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area.

4) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at the sprinkler.

5) The pressure loss assigned to the backflow device when included on a system in psi.

6) Friction factor and Reynold's number when the Darcy-Weibach equation is used.

8. Water allowance for outside hose shall be added to the sprinkler and inside hose requirement at the connection to the city water main or a yard hydrant, whichever is closer to the system riser.

E. Submittals shall be prepared by a qualified design professional currently employed by the contractor as follows:

1. Plans shall be prepared under the direct supervision of either a licensed professional engineer registered in the state of North Carolina or a NICET level III technician certified in water-based suppression systems.

2. The design professional shall be on good standing with the associated accreditation board and shall have paid all required board fees, performed all necessary renewal procedures, and paid any required state taxes or licensing fees associated with maintaining accreditation.

3. The design professional shall also affix their individual certification mark, indicating registration/certification number and their name as it is recorded with the associated accreditation board, and shall provide a unique signature to each sheet of the submittal.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 21 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data, manufacturer's warranties, and operation and maintenance instructions for the following:

1. Aboveground pipe and tube.

2. Pipe fittings.

3. Valves.

4. Sprinklers.

5. System attachments.

6. Hangers and supports.

7. System signage.

C. Project record documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations. Provide as-built hydraulic calculations.

1.5 SPARE STOCK

A. A supply of at least six (6) spare sprinklers shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced.

1. A minimum of two (2) sprinklers of each type and temperature rating shall be provided.

2. The sprinklers shall correspond to the types and temperature ratings of the sprinklers in the property.

B. The sprinklers shall be kept in a cabinet located where the temperature to which they are subjected will at no time exceed one hundred (100) degrees Fahrenheit.

C. Where dry sprinklers of different lengths are installed, spare dry sprinklers shall not be required, provided that a means of returning the system to service is furnished.

D. The stock of spare sprinklers shall include all types and ratings installed and shall be as follows:

1. For protected facilities having under three hundred (300) sprinklers – no fewer than six (6) sprinklers.

2. For protected facilities having three hundred (300) to one-thousand (1000) sprinklers – no fewer than twelve (12) sprinklers.

3. For protected facilities having over one thousand (1000) sprinklers – no fewer than twenty-four (24) sprinklers.

E. One sprinkler wrench as specified by the sprinkler manufacturer shall be provided in the cabinet for each type of sprinkler installed to be used for the removal and installation of sprinklers in the system.

F. A list of the sprinklers installed in the property shall be posted in the sprinkler cabinet. The list shall include the following:

1. Sprinkler identification number (SIN); or the manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure rating.

2. General description – including upright, pendent, sidewall, etc.

3. Quantity of each type to be contained in the cabinet.

4. Issue or revision date of the list.

1.6 LEVEL OF PROTECTION

A. A building, where protected by an automatic sprinkler system installation, shall be provided with sprinklers in all areas except where specific sections of NFPA 13 permit the omission of sprinklers.

1.7 SPECIAL CONSIDERATIONS

A. Additives or chemicals intended to stop leaks, such as sodium silicate or derivatives of sodium silicate, brine, or similar acting chemicals, shall not be used in sprinkler systems.

1. Biocides and other chemicals that are approved and used for prevention and mitigation of microbiologically influenced corrosion (MIC) and that do not adversely affect the fire-fighting properties of the water or the performance of the fire sprinkler system components are not prohibited.

B. Additives to the water supply intended for control of microbiological or other corrosion shall be listed for use within fire sprinkler systems.

C. Internal pipe coatings, excluding galvanizing, intended for control of microbiological or other corrosion shall be listed for use within fire sprinkler systems.

D. Sprinkler system components shall not be used to support non-sprinkler system components.

1.8 MATERIAL LISTING REQUIREMENTS

A. Materials or devices not specifically designated by NFPA 13 shall be used in accordance with all conditions, requirements, and limitations of their special listing.

1. All special listing requirements shall be included and identified in the product submittal literature and installation instructions.

B. Unless the requirements of the following are met, all materials and devices essential to successful system operation shall be listed:

1. Valve components (including valve trim, internal parts, gaskets, and the like) shall not be required to be individually listed.

2. The following equipment shall not be required to be listed:

a. Pipe or tube materials and dimensions as indicated in NFPA 13.

b. Fitting materials and dimensions as indicated in NFPA 13.

3. The following equipment shall not be required to be listed:

a. Hangers certified by a registered professional engineer as an acceptable approved alternate to the hanger requirements of NFPA 13.

b. Mild steel hangers formed from rods.

c. Fasteners certified by a registered professional engineer as part of a shared support structure.

4. Components that do not affect system performance such as drain piping, drain valves, and signs shall not be required to be listed.

1.9 RATED PRESSURE REQUIREMENTS

A. System components shall be rated for the maximum system working pressure to which they are exposed but shall not be rated at less than one-hundred-seventy-five (175) psi for components installed aboveground.

PART 2 PRODUCTS

2.1 ABOVEGROUND PIPE AND TUBE

A. Steel pipe: ASTM A53, ASTM A135, ASTM A795.

1. When joined by welding or roll-grooved piping and fittings, the minimum wall thickness for pressures up to three hundred (300) psi shall be schedule ten (10) for pipe sizes up to twelve (12) inches.

2. When jointed by threaded or cut-grooved piping and fittings, the minimum wall thickness for pressures up to three hundred (300) psi shall be schedule forty (40) for pipe sizes up to eight (8) inches.

B. Pipe and tube identification:

1. All pipe shall be marked along its length by the manufacturer in such a way as to properly identify the type of pipe.

a. Where indicated, the pipe identification can be covered with paint or other protective coatings before installation.

2. The marking shall be visible on every piece of pipe over two (2) feet long.

3. Pipe identification shall include the manufacturer’s name, model designation, or schedule.

2.2 PIPE FITTINGS

A. Cast iron: ASME B16.4, ASME B16.1.

1. Standard weight pattern cast iron fittings two (2) inches in size and smaller shall be permitted where pressures do not exceed three hundred (300) psi.

2. All other fittings shall be extra-heavy pattern where pressures exceed one-hundred-seventy-five (175) psi.

B. Malleable iron: ASME B16.3.

1. Standard weight pattern malleable iron fitting six (6) inches in size and smaller shall be permitted where pressures do not exceed three hundred (300) psi.

2. All other fittings shall be extra-heavy pattern where pressures exceed one-hundred-seventy-five (175) psi.

C. Steel: ASME B16.5, ASME B16.9, ASME B16.11, ASME B16.25, ASTM A234.

1. All fittings shall be extra-heavy pattern where pressures exceed one-hundred-seventy-five (175) psi.

D. Couplings and unions:

1. Screwed unions shall not be used on pipe larger than two (2) inches.

2. Couplings and unions of other than screwed type shall be of types listed specifically for use in sprinkler systems.

E. Reducers and bushings:

1. A one-piece reducing fitting shall be used wherever a change is made in the size of the pipe.

a. Hexagonal or face bushings shall be permitted in reducing the size of openings of fittings when standard fittings of the required size are not available.

b. In new installations, it shall be permitted to provide minimum one (1) inch outlets with hexagonal bushings to accommodate sprinklers attached directly to branch line fittings to allow for future system modifications.

2.3 VALVES

A. General requirements:

1. When water pressures exceed one-hundred-seventy-five (175) psi, valves shall be used in accordance with their pressure ratings.

B. Listed indicating valves:

1. Listed indicating valves shall not close in less than five (5) seconds when operated at maximum possible speed from the fully open position.

2. All valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves.

C. Wafer-type valves:

1. Wafer-type valves with components that extend beyond the valve body shall be installed in a manner that does not interfere with the operation of any system components.

D. Drain and test valves:

1. Drain valves and test valves shall be approved.

2.4 SPRINKLERS

A. Pendent:

1. Type: Concealed pendant type with matching screw on escutcheon plate.
2. Finish: White enamel.
3. Escutcheon plate finish: Coordinate with architectural drawings and provide escutcheon plate to match ceiling color.
4. Fusible link: Glass bulb type temperature rated for specific area hazard.

B. Upright:

1. Type: Standard upright type.
2. Finish: Brass.
3. Fusible link: Glass bulb type temperature rated for specific area hazard.

C. Guards: Finished to match sprinkler finish.

D. All sprinklers shall be permanently marked with one (1) or two (2) English uppercase alphabetic characters to identify the manufacturer, immediately followed by three (3) or four (4) numbers, to uniquely identify a sprinkler as to K-factor (orifice size) or orifice shape, deflector characteristic, pressure rating, and thermal sensitivity.

E. All sprinkler K-factors, relative discharge, and marking identification for sprinklers having different K-factors shall be in NFPA 13.

1. Listed sprinklers having pipe threads different from those shown NFPA 13 shall be permitted.

F. Sprinklers shall not be listed for protection of a portion of an occupancy classification.

G. Automatic sprinklers shall have their frame arms, deflector, coating material, or liquid bulb colored in accordance with the requirements of NFPA 13.

1. A dot on the top of the deflector, the color of the coating material, or colored frame arms shall be permitted for color identification of corrosion-resistant sprinklers.
2. Color identification shall not be required for ornamental sprinklers such as factory-plated or factory-painted sprinklers or for recessed, flush, or concealed sprinklers.
3. The frame arms of bulb-type sprinklers shall not be required to be color coded.
4. The liquid in bulb-type sprinklers shall be color coded in accordance with NFPA 13.

H. Sprinklers with ornamental finishes where utilized shall be specifically listed.

I. Plates, escutcheons, or other devices uses to cover the annular space around a sprinkler shall be metallic or shall be listed for use around a sprinkler.

1. Escutcheons used with recessed, flush-type, or concealed sprinklers shall be part of a listed sprinkler assembly.
2. Cover plates used with concealed sprinklers shall be part of the listed sprinkler assembly.

J. Temperature ratings:

1. Unless one of the following is met, ordinary and intermediate temperature sprinklers shall be used throughout.

   a. Where maximum ceiling temperatures exceed one hundred (100) degrees Fahrenheit, sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of NFPA 13 shall be used.

   b. High temperature sprinklers shall be permitted to be used throughout ordinary occupancies and as allowed by NFPA 13.

K. Thermal sensitivity:

1. Sprinklers in light hazard occupancies shall be of the quick response type.

2. Where quick response sprinklers are installed, all sprinklers within a compartment shall be quick response.

   a. Where there are no listed quick response sprinklers in the temperature range required, standard response sprinklers shall be permitted to be used.

L. Sprinklers shall have a minimum nominal K-factor of K-5.6.

M. Sprinklers having a K-factor exceeding K-5.6 and having one-half (1/2) inch national pipe thread shall not be installed in new sprinkler systems.

2.5 SYSTEM ATTACHMENTS

A. Waterflow alarm devices:

1. Waterflow alarm devices shall be listed for the service and so constructed and installed that any flow of water from a sprinkler system equal to or greater than that from a single automatic sprinkler of the smallest K-factor installed on the system will result in an audible alarm on the premises within five (5) minutes after such flow begins and until such flow stops.

B. Waterflow detection devices:

1. The alarm apparatus for a wet pipe system shall consist of a listed alarm check valve or other listed waterflow detection alarm device with the necessary attachments required to give an alarm.

2. Paddle-type waterflow alarm indicators shall be installed in wet systems only.

C. General attachments:

1. An alarm unit shall include a listed electric gong, bell, speaker, horn, or siren.

   a. Audible alarms shall be located on the outside of the building.

   b. Where desired by the owner, additional audible alarms shall be provided inside the building.

   c. Outdoor alarms shall not be required where audible alarms are part of a central station, auxiliary, remote station, or proprietary signaling fire alarm system, utilizing listed audible indoor alarm devices.

2. Outdoor electrically operated bells shall be weatherproofed and guarded.

   a. All alarm apparatus should be so located and installed that all parts are accessible for inspection, removal and repair, and such apparatus shall be substantially supported.

3. Piping between the sprinkler system and a pressure-actuated alarm-initiating device shall be galvanized steel, brass, copper, or other approved metallic corrosion-resistant material of not less than three-eighths (3/8) inch nominal pipe size.

D. Electrically operated attachments:

1. Electrically operated alarm attachments forming a part of an auxiliary, central station, local protective, proprietary, or remote station signaling system shall be installed in accordance with NFPA 72.

2. Sprinkler waterflow alarm systems that are not part of a required protective signaling system shall not be required to be supervised and shall be installed in accordance with NFPA 70, article 760.

3. Outdoor electric alarm devices shall be listed for outdoor use.

4. Where switches are provided that will silence electric alarm-sounding devices by interruption of electric current, then it shall be arranged so that, when the sounding device is electrically silenced, that fact shall be indicated by means of a conspicuous light located in the vicinity of the riser or alarm control panel.

a. This light shall remain in operation during the entire period of the electric circuit interruption.

E. Alarm device drains:

1. Drains from alarm devices shall be arranged so that there will be no overflowing at the alarm apparatus, at domestic connections, or elsewhere with the sprinkler drains wide open and under system pressure.

2.6 HANGERS AND SUPPORTS

A. Hangers certified by a registered professional engineer in the state of North Carolina that include all the following are an acceptable alternative to the prescriptive requirements of this specification:

1. Hangers shall be designed to support five times the weight of the water-filled pipe plus two-hundred-fifty (250) pounds at each point of piping support.

2. These points of support shall be adequate to support the system.

3. The spacing between hangers shall not exceed the value for the type of pipe as indicated in NFPA 13.

4. Hanger components shall be ferrous.

5. Detailed calculations shall be submitted showing stresses developed in hangers, piping, and fittings, and safety factors allowed.

B. Shared support structures shall be certified by a registered professional engineer in the state of North Carolina in accordance with the following:

1. The design of a shared support structure shall be based on either of the following:

a. Sprinkler pipe and other distribution systems shall be permitted to be supported from a shared support structure designed to support five (5) times the weight of water-filled sprinkler pipe and other supported distribution systems plus two-hundred-fifty (250) pounds, based on the allowable ultimate stress.

b. Sprinkler pipe and other distribution systems shall be permitted to be supported from a shared support structure designed to support five (5) times the weight of the water-filled sprinkler pipe plus two-hundred-fifty (250) pounds, and one-and-one-half (1.5) times the weight of all other supported distribution systems.

2. The building structure shall not be considered a shared support structure.

3. Systems that are incompatible with the fire sprinkler systems based on vibration, thermal expansion and contraction, or other factors shall not share support structures.

C. Component material:

1. Hangers and their components shall be ferrous.

a. Holes through solid structural members shall be permitted to serve as hangers for the support of system piping provided such holes are permitted by the structural engineer and the spacing and support provisions for hangers of NFPA 13 are satisfied.

D. Trapeze hangers:

1. The minimum size of steel angle or pipe span between purlins or joists shall be such that the section modulus required in NFPA 13 does not exceed the available section modulus of the trapeze member from NFPA 13.

2. Any other sizes or shapes giving equal or greater section modulus shall be acceptable.

3. All angles shall be installed with the longer leg vertical.

4. The trapeze member shall be secured to prevent slippage.

5. All components of each hanger assembly that attach to a trapeze member shall conform to the material listing requirements and be sized to support the suspended sprinkler pipe.

6. The ring, strap, or clevis installed on a pipe trapeze shall be manufactured to fit the pipe size of the trapeze member.

7. Holes for bolts shall not exceed one-sixteenth (1/16) inch greater than the diameter of the bolt.

8. Bolts shall be provided with a flat washer and nut.

E. Support of non-system components:

1. Sprinkler piping or hangers shall not be used to support non-system components.

2. Sprinkler piping shall be permitted to utilize shared support structures.

F. Hanger rods:

1. Hanger rod size shall be the same as that approved for use with the hanger assembly, and the size of rods shall not be less than that given in NFPA 13.

2. Where the pitch of the branch line is six (6) in twelve (12) or greater, a reduction in the lateral loading on branch line hanger rods shall be done by one of the following:

a. Second hanger installed in addition to the required main hangers.

b. Lateral sway brace assemblies on the mains.

c. Branch line hangers utilizing an articulating structural attachment.

d. Equivalent means providing support to the branch line hanger rods.

3. The size of the rod material of U-hooks shall not be less than that given in NFPA 13.

4. Eye rods:

a. The size of the rod material for eye rods shall not be less than specified in NFPA 13.

b. Eye rods shall be secured with lock washers to prevent lateral motion.

5. Threaded sections of rods shall not be formed or bent.

G. Fasteners in concrete:

1. The use of listed inserts set in concrete and listed post-installed anchors to support hangers shall be permitted for mains and branch lines.

a. Post-installed anchors shall not be used in cinder concrete, except for branch lines where the post-installed anchors are alternated with through-bolts or hangers attached to beams.

b. Post-installed anchors shall not be used in ceilings of gypsum or other similar soft material.

2. Post-installed anchors shall be installed in a horizontal position in the sides of concrete beams.

a. Post-installed anchors shall be permitted to be installed in the vertical position under any of the following conditions:

1) When used in concrete having gravel or crushed stone aggregate to support pipes four (4) inches or less in diameter.

2) When post-installed anchors are alternated with hangers connected directly to the structural members, such as trusses and girders, or to the sides of concrete beams to support pipes five (5) inches or larger.

3) When post-installed anchors are spaced not over ten (10) feet apart to support pipe four (4) inches or larger.

3. Holes for post-installed anchors in the side of beams shall be above the centerline of the beam or above the bottom reinforcement steel rods.

4. Holes for post-installed anchors used in the vertical position shall be drilled to provide uniform contact with the shield over its entire circumference.

5. The depth of the post-installed anchor hole shall not be less than specified for the type of shield used.

6. Powder-driven studs:

a. Powder-driven studs, welding units, and the tools used for installing these devices shall be listed.

b. Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

c. Representative samples of concrete into which studs are to be driven shall be tested to determine that the studs will hold a minimum load of seven-hundred-fifty (750) pounds for two (2) inches of smaller pipe; one-thousand (1000) pounds for two-and-one-half (2.5) to three-and-one-half

(3.5) inches pipe; and one-thousand-two-hundred (1200) pounds for four (4) or five (5) inches pipe.

d. Increaser couplings shall be attached directly to the powder-driven studs.

7. Minimum bolt size for concrete:

a. The size of a bolt used with a hanger and installed through concrete shall not be less than specified in NFPA 13.

b. Holes for bolts shall not exceed one-sixteenth (1/16) inch greater than the diameter of the bolt.

c. Bolts shall be provided with a flat washer and nut.

H. Fasteners in steel:

1. Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed.

a. Powder-driven studs shall not be used in steel of less than three-sixteenths (3/16) inch total thickness.

2. Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

3. Increaser couplings shall be attached directly to the powder-driven studs or welding studs.

4. Welding studs or other hanger parts shall not be attached by welding to steel less than US standard twelve (12) gauge.

5. Minimum bolt size for steel:

a. The size of a bolt used with a hanger and installed through steel shall not be less than specified in NFPA 13.

b. Holes for bolts shall not exceed one-sixteenth (1/16) inch greater than the diameter of the bolt.

c. Bolts shall be provided with a flat washer and nut.

2.7 SYSTEMS SIGNAGE

A. Systems signage shall be as indicated in NFPA 13.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Automatic sprinkler systems shall be automatically activated.

3.2 WATER SUPPLY REQUIREMENTS

A. Water supplies for automatic sprinkler systems shall comply with NFPA 13 and the requirements of this section.

B. The potable water supply to automatic sprinkler and standpipe systems shall be protected against backflow as required by the North Carolina Plumbing Code.

3.3 SYSTEM SUPERVISION AND ALARM

A. All valves controlling the water supply for automatic sprinkler systems, pumps, tanks, water levels and temperatures, critical air pressures, and water-flow switches on all sprinkler systems shall be electrically supervised by a listed fire alarm control unit.

B. Alarm, supervisory, and trouble signals shall be distinctly different and shall be automatically transmitted to an approved supervising station or, when approved by the fire code official, shall sound an audible signal at a constantly attended location.

1. In occupancies required to be equipped with a fire alarm system, the backflow preventer valves shall be electrically supervised by a tamper switch installed in accordance with NFPA 72 and separately annunciated.

C. Approved audible devices shall be connected to every automatic sprinkler system. Such sprinkler water-flow alarm devices shall be activated by water flow equivalent to the flow of a single sprinkler of the smallest orifice size installed in the system.

D. Alarm devices shall be provided on the exterior of the building in an approved location.

E. Where a fire alarm system is installed, actuation of the automatic sprinkler system shall actuate the building fire alarm system.

3.4 PIPING INSTALLATION

A. Pipe and tube bending:

1. Bending of schedule ten (10) steel pipe, or any steel pipe of wall thickness equal to or greater than schedule ten (10), shall be permitted when bends are made with no kinks, ripples, distortions, or reductions in diameter or any noticeable deviations from round.

2. For all other steel pipe, the minimum radius of a bend shall be twelve (12) pipe diameters for all sizes.

B. Drainage:

1. General:

a. All sprinkler pipe and fittings shall be installed so that the system can be drained.

1) All piping shall be arranged where practicable to drain to the main drain valve.

b. On wet pipe systems, sprinkler pipes shall be permitted to be installed level.

c. Trapped piping shall be drained in accordance with the requirements for auxiliary drains.

2. System, main drain, or sectional drain connections:

a. Provisions shall be made to properly drain all parts of the system.

b. Drain connections for system supply risers and mains shall be sized in accordance with NFPA 13.

c. Where an interior sectional or floor control valve is provided, it shall be provided with a drain connection having a minimum size in accordance with NFPA 13 to drain that portion of the system controlled by the sectional valve.

d. Drains shall discharge outside or to a drain connection capable of handling the flow of the drain.

e. The test connection of pressure type contactors or water motor operated alarm devices shall be permitted to be used as main drain connections.

f. Where subject to freezing, a minimum four (4) feet of exposed drain pipe shall be in a heated area between the drain valve and the exterior wall when drain piping extends through the wall to the outside.

3. Auxiliary drains:

a. Auxiliary drains shall be provided where a change in piping direction prevents drainage of system piping through the main drain valve.

b. Where the capacity of isolated trapped sections of pipe is fifty (50) gallons or more, the auxiliary drain shall consist of a valve not smaller than one (1) inch, piped to an accessible location.

c. Where the capacity of isolated trapped sections of pipe is more than five (5) gallons and less than fifty (50) gallons, the auxiliary drain shall consist of a valve three-quarters (3/4) inch or larger and a plug or a nipple and cap.

d. Where the capacity of trapped sections of pipes is less than five (5) gallons, one of the following arrangements shall be provided:

1) An auxiliary drain shall consist of a nipple and cap or plug not less than one-half (1/2) inch in size.

2) An auxiliary drain shall not be required for trapped sections less than five (5) gallons where the system piping can be drained by removing a single pendent sprinkler.

3) Where flexible couplings or other easily separated connections are used, the nipple and cap or plug shall be permitted to be omitted.

e. Tie-in drains shall not be required on wet pipe system protecting nonfreezing environments.

4. Discharge of drain valves:

a. Direct interconnections shall not be made between sprinkler drains and sewers.

b. The drain discharge shall conform to any local heath or water department regulations.

c. Where drainpipes are buried underground, approved corrosion resistant pipe shall be used.

d. Drainpipes shall not terminate in blind spaces under the building.

e. Where exposed to the atmosphere, drainpipes shall be fitted with a turned down elbow.

f. Drainpipes shall be arranged to avoid exposing any of the water-filled portion of the sprinkler system to freezing conditions.

C. Provisions for flushing systems:

1. All sprinkler systems shall be arranged for flushing.

2. Readily removable fittings shall be provided at the end of all cross mains.

3. All cross mains shall terminate in one-and-one-quarter (1.25) inches or larger pipe.

4. All branch lines on gridded systems shall be arranged to facilitate flushing.

D. Protection of piping:

1. Protection of piping against corrosion:

a. Where approved, the pipe identification can be covered with paint or other protective coatings before installation.

b. Where corrosive conditions are known to exist due to moisture or fumes from corrosive chemicals or both, special types of fittings, pipes and hangers that resist corrosion shall be used, or a protective coating shall be applied to all unprotected exposed surfaces of the sprinkler system.

c. Where water supplies or environmental conditions are known to have unusual corrosive properties, piping shall have a corrosion resistance ratio of one (1) or more, and the system shall be treated in accordance with NFPA 13.

d. Where corrosive conditions exist or piping is exposed to the weather, corrosion resistant types of pipe, fittings, and hangers or protective corrosion resistant coatings shall be used.

e. Where steel pipe is used underground, the pipe shall be protected against corrosion.

3.5 PIPE FITTING INSTALLATION

A. Threaded pipe and fittings:

1. All threaded pipe and fittings shall have threads cut to ASME B1.20.1.

2. Steel pipe with wall thickness less than schedule forty (40) less than eight (8) inches in diameter shall only be permitted to be joined by threaded fittings where the threaded assembly is investigated for suitability in automatic sprinkler installations and listed for this service.

3. Joint compound or tape shall be applied only to male threads.

B. Welded pipe and fittings:

1. Fabrication:

a. When welding sprinkler pipe, the pipe shall be shop welded.

1) Where any part of the piping system is to be welded in place, welding of sprinkler piping shall be permitted where the welding process is performed in accordance with NFPA 51B and the mechanical fittings required by NFPA 13 are provided.

2) Tabs for longitudinal earthquake bracing shall be permitted to be welded to in-place piping where the welding process is performed in accordance with NFPA 51B.

b. Welding shall not be performed where there is impingement of rain, snow, sleet, or high wind on the weld area of the pipe product.

c. Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.

2. Fittings:

a. Welded fittings used to join pipe shall be listed fabricated or manufactured fittings.

1) Listed, shaped, and contoured nipples meet the definition of fabricated fittings.

b. Fittings shall be joined in conformance with a qualified welding procedure as set forth in this section and shall be an acceptable product under this standard, provided the materials and wall thickness are compatible with other sections of this standard.

c. Fittings shall not be required where pipe ends are buttwelded.

d. When the pipe size in a run of piping is reduced, a reducing fitting designed for that purpose shall be used.

3. Welding requirements:

a. Welds between pipe and welded outlet fittings shall be permitted to be attached by full penetration welds, partial penetration groove welds, or fillet welds.

b. The minimum throat thickness shall be not less than the thickness of the pipe, the thickness of the welding fitting, or three-sixteenths (3/16) inch, whichever is least.

c. Circumferential butt joints shall be cut, beveled, and fit so that full penetration is achievable.

d. Full penetration welding shall not be required.

e. Where slip-on flanges are welded to pipe with a single fillet weld, the weld shall be on the hub side of the flange and the minimum throat weld thickness shall not be less than one-and-one-quarter (1.25) times the pipe wall thickness or the hub thickness, whichever is less.

1) Face welds on the internal face of the flange shall be permitted as a water seal in addition to a hub weld.

f. Tabs for longitudinal earthquake bracing shall have minimum throat weld thickness not less than one-and-one-quarter (1.25) times the pipe wall thickness and welded on both sides of the longest dimension.

g. When welding is performed, the following shall apply:

1) Holes in piping for outlets shall be cut to the full inside diameter of fittings prior to welding in place of the fittings.

2) Discs shall be retrieved.

3) Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.

4) Fittings shall not penetrate the internal diameter of the piping.

5) Steel plates shall not be welded to the ends of piping or fittings.

6) Fittings shall not be modified.

7) Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings, except as specifically permitted.

8) Completed welds shall be free from cracks, incomplete fusion, surface porosity greater than one-sixteenth (1/16) inch diameter and undercut deeper than twenty-five (25) percent of the wall thickness or one-thirty-seconds (1/32) inch, whichever is less.

9) Completed circumferential butt weld reinforcement shall not exceed three-thirty-seconds (3/32) inch.

4. Qualifications:

a. A welding procedure shall be prepared and qualified by the contractor or fabricator before any welding is done.

b. Qualification of the welding procedure to be used and the performance of all welders and welding operators shall be required and shall meet or exceed the requirements of AWS B2.1, or ASME Boiler and Pressure Vessel Code, Section IX, or other applicable qualification standard as required by the authority having jurisdiction.

1) Successful procedure qualification of complete joint penetration groove welds shall qualify partial joint penetration (groove/fillet) welds and fillet welds in accordance with the provisions of NFPA 13.

c. Welding procedures qualified under standards recognized by previous editions of NFPA 13 shall be permitted to be continued in use.

1) Each contractor or fabricator shall have available to the authority having jurisdiction an established written quality assurance procedure ensure compliance.

d. Contractors or fabricators shall be responsible for all welding they produce.

5. Records:

a. Welders or welding machine operators shall, upon completion of each welded pipe, place their identification mark or label onto each piece adjacent to a weld.

b. Contractors or fabricators shall maintain certified records, which shall be available to the authority having jurisdiction, or the procedures used, and the welders or welding machine operators employed by them, along with their welding identification.

c. Records shall show the date and the results of procedure and performance qualifications.

C. Grooved joints:

1. Pipe, fittings, valves, and devices to be joined with grooved couplings shall contain cut, rolled, or cast grooves that are dimensionally compatible with the couplings.

a. Pipe fittings, valves, devices, and couplings that conform with or are listed in compliance with standardized groove specifications shall be considered compatible.

b. Other groove dimensions and grooving methods shall be acceptable when investigated for suitability in automatic sprinkler installations and listed for this service shall be permitted where installed in accordance with their listing limitations, including installation instructions.

D. Outlet fittings:

1. Rubber-gasketed outlet fittings that are used on sprinkler systems shall meet the following requirements:

a. Be installed in accordance with the listing and manufacturer's installation instructions.

b. Have all disks retrieved.

c. Have smooth bores cut into the pipe, with all cutting residue removed.

d. Not be modified.

E. End treatment:

1. After cutting, pipe ends shall have burrs and fins removed.

2. Pipe used with listed fittings and its end treatment shall be in accordance with the fitting manufacturer's installation instructions and the fitting's listing.

3.6 VALVE INSTALLATION

A. Identification:

1. All control, drain, and test connection valves shall be provided with permanently marked weatherproof metal or rigid plastic identification signs.

2. The identification sign shall be secured with corrosion-resistant wire, chain, or other approved means.

3. The control valve sign shall identify the portion of the building served.

a. Systems that have more than one (1) control valve that must be closed to work on a system or space shall have a sign referring to existence and location of other valves.

B. Relief valves:

1. A wet pipe system shall be provided with a listed relief valve not less than one-half (1/2) inch in size and set to operate at one-hundred-seventy-five (175) psi or ten (10) psi in excess of the maximum system pressure, whichever is greater.

a. Where auxiliary air reservoirs are installed to absorb pressure increases, a relief valve shall not be required.

C. Control valves:

1. General installation requirements:

a. Each sprinkler system shall be provided with a listed indicating valve in an accessible location, so located as to control all automatic sources of water supply.

1) All valves controlling water supplies for sprinkler systems or portions thereof, including floor control valves, shall be accessible to authorized persons during emergencies.

2) Permanent ladders, clamped treads on risers, chain-operated hand wheels, or other accepted means should be provided where necessary.

b. At least one listed indicating valve shall be installed in each source of water supply.

c. These requirements shall not apply to fire department connections, and there shall be no shutoff valve in the fire department connection.

2. Supervision:

a. Valves on connections to water supplies, sectional control and isolation valves, and other valves in supply pipes to sprinklers and other fixed water-based suppression systems shall be supervised by one of the following methods:

1) Central station, proprietary, or remote station signaling service.

2) Local signaling service that will cause the sounding of an audible signal at a constantly attended point.

3) Valves locked in the correct position.

4) Valves located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly as part of an approved procedure.

b. These requirements shall not apply to underground gate valves with roadway boxes.

c. Where control valves are installed overhead, they shall be positioned so that the indicating feature is visible from the floor below.

d. A listed backflow prevention assembly shall be permitted to be considered a control valve, provided both control valves are listed for fire protection system use and an additional control valve shall not be required.

3. Check valves:

a. Where there is more than one source of water supply, a check valve shall be installed in each connection.

b. A listed backflow prevention device shall be considered a check valve, and an additional check valve shall not be required.

c. Check valves shall be installed in a vertical or horizontal position in accordance with their listing.

4. Control valves with check valves:

a. In a connection serving as one source of supply, listed indicating valves or post indicator valves shall be installed on both sides of all check valves.

1) This requirement shall not apply to the check valve located in the fire department connection piping, and there shall be no control valves in the fire department connection piping.

2) This requirement shall not apply where the city connection serves as the only automatic source of supply to a wet pipe sprinkler system; a control valve is not required on the system side of the check valve or the alarm check valve.

b. The city services control valve (non-indicating control valve) shall be permitted to serve as the supply side control valve.

5. All control valves shall be located where accessible and free of obstructions.

6. Identification signs shall be provided at each valve to indicate its function and what it controls.

3.7 SPRINKLER INSTALLATION

A. Sprinklers shall be installed throughout in accordance with NFPA 13.

1. Automatic sprinklers shall not be required in the following rooms or areas where such rooms or areas are protected with an approved automatic fire detection system in accordance with the North Carolina Fire Prevention Code that will respond to visible or invisible particles of combustion:

a. Any room where the application of water, or flame and water, constitutes a serious life or fire hazard.

b. Any room or space where sprinklers are considered undesirable because of the nature of the contents, when approved by the fire code official.

c. Generator and transformer rooms separated from the remainder of the building by walls and floor/ceiling or roof/ceiling assemblies having a fire-resistance rating of not less than two (2) hours.

d. Rooms or areas that are of noncombustible construction with wholly noncombustible contents.

e. Fire service access elevator machine rooms and machinery spaces.

2. Sprinklers will not be omitted from any room merely because it is damp, of fire-resistance rated construction, or contains electrical equipment.

B. Quick-response automatic sprinklers shall be installed in the following areas in accordance with their listings:

1. Light-hazard occupancies as defined in NFPA 13.

C. Automatic sprinklers shall be installed with due regard to obstructions that will delay activation or obstruct the water distribution pattern.

1. Automatic sprinklers shall be installed in or under covered kiosks, displays, booths, concession stands, or equipment that exceeds four (4) feet in width.

a. Kitchen equipment under exhaust hoods protected with an alternative fire-extinguishing system installed in accordance with the North Carolina Fire Prevention code shall not require automatic sprinkler protection.

D. Only new sprinklers shall be installed.

1. When a sprinkler has been removed for any reason, it shall not be reinstalled.

E. Listed corrosion-resistant sprinklers shall be installed in locations where chemicals, moisture, or other corrosive vapors sufficient to cause corrosion of such devices exist.

1. Corrosion-resistant coatings shall be applied only by the manufacturer of the sprinkler.

a. Care shall be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating.

b. Any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in the approved manner so that no part of the sprinkler will be exposed after installation has been completed.

F. Sprinklers shall only be painted by the sprinkler manufacturer.

1. Where sprinklers have had paint applied by other than the sprinkler manufacturer, they shall be replaced with new listed sprinklers of the same characteristics, including K-factor, thermal response, and water distribution.
2. Where cover plates on concealed sprinklers have been painted by other than the sprinkler manufacturer, the cover plate shall be replaced.

G. Ornamental finishes shall only be applied to sprinklers and, if applicable, their concealed cover plates, by the sprinkler manufacturer.

H. The use of caulking or glue to seal the penetration or to affix the components of a recessed escutcheon or concealed cover plate shall not be permitted.

I. Sprinklers subject to mechanical injury shall be protected with listed guards.

J. Sprinklers shall be installed in accordance with their listing.

K. Sprinklers shall be installed in the center of each ceiling tile for acoustical tile ceilings and centered between light fixtures in gypsum, or other, hard ceilings.

L. Upright sprinklers shall be installed with the frame arms parallel to the branch line, unless specifically listed for other orientation.

M. Protective caps and straps:

1. Protective caps and straps shall be removed using means that are in accordance with the manufacturer's installation instructions.
2. Protective caps and straps shall be removed from all sprinklers prior to the time when the sprinkler system is placed in service.
   a. Protective caps and straps shall not be removed until construction has progressed to the point where the sprinklers will not be subjected to damage.
   b. Protective caps on sidewall and pendent sprinklers shall remain until the wall and ceiling systems are complete and shall be removed as finish escutcheons are installed.
   c. Protective caps and straps on all upright sprinklers or on any sprinklers installed more than ten (10) feet above the floor shall be permitted to be removed from sprinklers immediately following their installation.

N. Application of sprinkler types:

1. Standard upright and pendent spray sprinklers:
   a. Upright and pendent spray sprinklers shall be permitted in all occupancy hazard classifications and building construction types.
2. Extended coverage sprinklers shall only be installed as follows:
   a. Unobstructed construction consisting of flat, smooth ceilings with a slope not exceeding a pitch of two (2) in twelve (12).
   b. Unobstructed or noncombustible obstructed construction, where specifically listed for such use.
   c. Within trusses or bar joists having web members not greater than one (1) inch maximum dimension or where trusses are spaced greater than seven-and-one-half (7.5) feet on center and where the ceiling does not exceed a pitch of two (2) in twelve (12).

d. Extended coverage upright and pendent sprinklers installed under smooth, flat ceilings that have slopes not exceeding a pitch of four (4) in twelve (12), where specifically listed for such use.

e. Extended coverage sidewall sprinklers installed in accordance with NFPA 13 in slopes exceeding a ceiling pitch of two (2) in twelve (12) where listed for such use.

f. In each bay of obstructed construction consisting of solid structural members that extend below the deflector of the sprinkler.

O. Position, location, spacing, and use of sprinklers:

1. Sprinklers shall be located, spaced, and positioned in accordance with the requirements of NFPA 13.

2. Sprinklers shall be positioned to provide protection of the area consistent with the overall objectives of NFPA 13 by controlling the positioning and allowable area of coverage for each sprinkler.

3.8 SYSTEM ATTACHMENTS

A. Waterflow alarms:

1. A local waterflow alarm shall be provided on every sprinkler system having more than twenty (20) sprinklers.

B. Retarding devices:

1. On each alarm check valve used under conditions of variable water pressure, a retarding device shall be installed.

C. Alarm bypass test connections:

1. Alarm valves shall be fitted with an alarm bypass test connection for an electric alarm switch, water motor gong, or both.

2. The alarm bypass test connection for alarm valves shall be made on the water supply side of the system and provided with a control valve and drain for the alarm piping.

3. The alarm bypass connection for alarm valves at the riser shall be permitted to be made on the system side of an alarm valve.

D. Indicating control valves:

1. Where a control valve is installed in the connection to pressure-type contactors or water motor-operated alarm devices, it shall be of the indicating type.

2. Such valves shall be sealed, locked, or electrically supervised in the open position.

E. Mechanically operated attachments:

1. Where a retarding chamber is used in connection with an alarm valve, the strainer shall be located at the outlet of the retarding chamber unless the retarding chamber is provided with an approved integral strainer in its outlet.

F. Gauges:

1. An approved pressure gauge shall be installed in each system riser.

2. Pressure gauges shall be installed above and below each alarm check valve or system riser check valve where such devices are present.

3. A pressure gauge with a connection not smaller than one-quarter (1/4) inch shall be installed at the system main drain, at each main drain associated with a floor control valve, and on the inlet and outlet side of each pressure-reducing valve.

4. Each gauge connection shall be equipped with a shutoff valve and provisions for draining.

5. The required pressure gauges shall be approved, and they shall have a maximum limit not less than twice the normal system working pressure at the point where installed.

6. Gauges shall be installed to permit removal and shall be located where they will not be subject to freezing.

G. System connections:

1. Main drain test connections:

a. Main drain test connections shall be provided at locations that will permit flow tests of water supplies and connections.

b. They shall be so installed that the valve can be opened wide for a sufficient time to assure a proper test without causing water damage.

c. Main drain test connections shall be sized in accordance with the requirements for main drains.

2. Alarm test connections:

a. An alarm test connection not less than one (1) inch in diameter, terminating in a smooth bore corrosion-resistant orifice, giving a flow equal to or less than one sprinkler of a type having the smallest K-factor installed on the system, shall be provided to test each waterflow alarm device for each system.

b. The test connection shall be accessible.

c. The discharge shall be made to the outside, to a drain connection capable of accepting full flow under system pressure, or to another location where water damage will not result.

d. The alarm test connection shall be permitted to be installed in any location on the fire sprinkler system downstream of the waterflow alarm.

3.9 HANGER AND SUPPORT INSTALLATION

A. General requirements:

1. Ceiling sheathing:

a. Sprinkler piping shall be supported independently of the ceiling sheathing.

1) Fasteners used to support sprinkler system piping shall not be attached to ceilings of gypsum or other similar soft material.

b. Toggle hangers shall be permitted only for the support of pipe one-and-one-half (1.5) inches or smaller in size under ceilings of hollow tile or metal lath and plaster.

2. Building structure:

a. Sprinkler piping shall be substantially supported from the building structure, which must support the added load of the water-filled pipe plus a minimum of two-hundred-fifty (250) pounds applied at the point of hanging, except where explicitly permitted by NFPA 13.

b. Trapeze hangers shall be used where necessary to transfer loads to appropriate structural members.

3. Metal deck:

a. Branch line hangers attached to metal deck shall be permitted only for the support of pipe one (1) inch or smaller in size, by drilling or punching the vertical portion of the metal deck and using through bolts.

b. The distance from the bottom of the bolt hole to the bottom of the vertical member shall be not less than three-eighths (3/8) inch.

4. Where sprinkler piping is installed below ductwork, piping shall be supported from the building structure or from the ductwork supports, provided such supports are capable of handling both the load of the ductwork and the load required of the sprinkler piping.

B. Maximum distance between hangers:

1. The maximum distance between hangers shall not exceed that specified in NFPA 13, except where the provisions for location of hangers for mains apply.

C. Location of hangers on branch lines:

1. This section shall apply to the support of steel pipe and is subject to the provisions for maximum distance between hangers.

2. Minimum number of hangers:

a. There shall not be less than one (1) hanger for each section of pipe.

b. Where sprinklers are spaced less than six (6) feet apart, hangers spaced up to a maximum of twelve (12) feet shall be permitted.

c. For welded or mechanical outlets on a continuous section of pipe, hanger spacing shall be in accordance with NFPA 13.

d. Starter lengths less than six (6) feet shall not require a hanger, unless on the end line of a side feed system or where an intermediate cross main hanger has been omitted.

e. A single section of pipe shall not require a hanger when the cumulative distance between hangers on the branch line does not exceed the spacing required by NFPA 13.

3. The distance between a hanger and the centerline of an upright sprinkler shall not be less than three (3) inches.

4. Unsupported lengths:

a. For steel pipe, the unsupported horizontal length between the end sprinkler and the last hanger on the line shall not be greater than thirty-six (36) inches for one (1) inch pipe, forty-eight (48) inches for one-and-one-quarter (1.25) inches pipe, and sixty (60) inches for one-and-one-half (1.5) inches or larger pipe.

b. Where the limits prescribed above are exceeded, the pipe shall be extended beyond the end sprinkler and shall be supported by an additional hanger.

c. Unsupported length with maximum pressure exceeding one hundred (100) psi and branch line above ceiling supplying sprinklers in pendent position below ceiling:

1) Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds one hundred (100) psi and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the hanger assembly supporting the pipe supplying an end sprinkler in a pendent position shall be of a type that prevents upward movement of the pipe.

2) The unsupported length between the end sprinkler in a pendent position or drop nipple and the last hanger on the branch line shall not be greater than twelve (12) inches for steel pipe.

3) Where this limit is exceeded, the pipe shall be extended beyond the end sprinkler and supported by an additional hanger.

4) The hanger closest to the sprinkler shall be of a type that prevents upward movement of the pipe.

5. Unsupported armover length:

a. The cumulative horizontal length of an unsupported armover to a sprinkler, sprinkler drop, or sprig shall not exceed twenty-four (24) inches for steel pipe.

b. Unsupported armover length with maximum pressure exceeding one hundred (100) psi and branch line above ceiling supplying sprinklers in pendent position below ceiling:

1) Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds one hundred (100) psi and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the cumulative horizontal length of an unsupported armover to a sprinkler or sprinkler drop shall not exceed twelve (12) inches for steel pipe.

2) The hanger closest to the sprinkler shall be of a type that prevents upward movement of the pipe.

6. Wall-mounted sidewall sprinklers shall be restrained to prevent movement.

7. Sprigs four (4) feet or longer shall be restrained against lateral movement.

D. Location of hangers on mains:

1. Hangers for mains shall be in accordance with the maximum distance between hangers between each branch line, or on each section of pipe, whichever is the lesser dimension.

2. For welded or mechanical outlets on a continuous section of pipe, hanger spacing shall be in accordance with NFPA 13.

3. For cross mains in steel pipe systems in bays having two (2) branch lines, the intermediate hanger shall be permitted to be omitted, provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits.

a. The remaining branch line hangers shall be installed in accordance with the requirements for the location of hangers on branch lines.

4. For cross mains in steel pipe systems only in bays having three (3) branch lines, either side or center feed, only one intermediate hanger shall be permitted to be omitted, provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits.

   a. The remaining branch line hangers shall be installed in accordance with the requirements for the location of hangers on branch lines.

5. For cross mains in steel pipe systems only in bays having four (4) or more branch lines, either side or center feed, two (2) intermediate hangers shall be permitted to be omitted, provided that the maximum distance between hangers does not exceed the maximum distance between hangers and a hanger attached to a purlin on each branch line is located as near to the cross main as the purlin permits.

6. At the end of the main, intermediate trapeze hangers shall be installed unless the main is extended to the next framing member with a hanger installed at this point, in which event an intermediate hanger shall be permitted to be omitted as previous described above.

7. A single section of pipe shall not require a hanger when the cumulative distance between hangers on the main does not exceed the spacing required by NFPA 13.

E. Support of risers:

1. Riser shall be supported by riser clamps or by hangers located on the horizontal connections within twenty-four (24) inches of the centerline of the riser.

2. Riser clamps supporting risers by means of set screws shall not be used.

3. Riser clamps anchored to walls using hanger rods in the horizontal position shall not be permitted to vertically support risers.

4. Multistory buildings:

   a. In multistory buildings, riser supports shall be provided at the lowest level, at each alternate level above, above and below offsets, and at the top of the riser.

   b. Supports above the lowest level shall also restrain the pipe to prevent movement by an upward thrust where flexible fittings are used.

   c. Where risers are supported from the ground, the ground support shall constitute the first level of riser support.

   d. Where risers are offset or do not rise from the ground, the first ceiling level above the offset shall constitute the first level or riser support.

5. Distance between supports for risers shall not exceed twenty-five (25) feet.

F. Pipe stands:

1. Pipe stands shall be sized to support a minimum of five (5) times the weight of the water-filled pipe plus two-hundred-fifty (250) pounds.

2. The pipe stand base shall be secured by an approved method.

3. Where pipe stands are utilized, they shall be approved.

3.10 SYSTEM SIGNAGE INSTALLATION

A. Hydraulic design information sign:

1. The installing contractor shall identify a hydraulically designed sprinkler system with a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means. Such signs shall be placed at the alarm valve supplying the corresponding hydraulically designed area.
2. The sign shall include the following information:
    a. Location of the design area(s).
    b. Discharge densities over the design area(s).
    c. Required flow and residual pressure demand at the base of the riser.
    d. Occupancy classification or commodity classification and maximum permitted storage height and configuration.
    e. Hose stream allowance included in addition to the sprinkler demand.
    f. The name of the installing contractor.

B. General information sign:
1. The installing contractor shall provide a general information sign used to determine system design basis and information relevant to the inspection, testing, and maintenance requirements required by NFPA 25.
2. Such general information shall be provided with a permanently marked weatherproof metal or rigid plastic sign, secured with corrosion-resistant wire, chain, or other acceptable means.
3. Such signs shall be place at each system control valve and auxiliary system control valve.
4. The sign shall include the following information:
    a. Name and location of the facility protected.
    b. Occupancy classification.
    c. Flow test data.
    d. Original results of main drain flow test.
    e. Name of installing contractor or designer.
    f. Indication of presence and location of auxiliary systems.
    g. Where injection systems are installed to treat MIC or corrosion, the type of chemical, concentration of the chemical, and where information can be found as to the proper disposal of the chemical.

3.11 INSPECTION

A. Spot checks shall be performed to ensure that the sprinkler identification number(s) on the plans match those that have been installed. No less than twenty-five (25) percent of each different sprinkler shall be inspected.

3.12 SYSTEM ACCEPTANCE TESTS

A. Hydrostatic tests:
1. All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at two hundred (200) psi and shall maintain that pressure without loss for two (2) hours.

2. Portions of systems normally subjected to system working pressures in excess of one-hundred-fifty (150) psi shall be tested at a pressure of fifty (50) psi in excess of system working pressure and shall maintain that pressure without loss for two (2) hours.

3. Loss shall be determined by a drop in gauge pressure or visual leakage.

4. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested. The pressures in piping at higher elevations shall be permitted to be less than two hundred (200) psi when accounting for elevation losses. Systems of portions of systems that can be isolated shall be permitted to be tested separately.

5. Additives, corrosive chemicals such as sodium silicate, or derivatives of sodium silicate, brine, or similar acting chemicals shall not be used while hydrostatically testing systems for stopping leaks.

6. Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system. After repair or replacement work affecting the fire department connection, the piping between the exterior and the check valve in the fire department inlet pipe shall be isolated and hydrostatically testing at one-hundred-fifty (150) psi.

7. When systems are being hydrostatically tested, tests shall be permitted to be conducted with pendent or horizontal sidewall sprinklers or plugs installed in fittings. Any plugs shall be replaced with pendent or horizontal sidewall sprinklers after the test is completed.

8. Provision shall be made for the proper disposal of water used for flushing or testing.

9. Test blanks:

   a. Test blanks shall have painted lugs protruding in such a way as to clearly indicate their presence.

   b. The test blanks shall be numbered, and the installing contractor shall have a recordkeeping method ensuring their removal after work is completed.

   c. When subject to hydrostatic test pressures, the clapper of a differential-type valve shall be held off its seat to prevent damaging the valve.

B. System operational tests:

1. Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspector’s test connection and shall result in an audible alarm on the premises within five (5) minutes after such flow begins and until such flow stops.

2. Main drain valves:

   a. The main drain valve shall be opened and remain open until the system pressure stabilizes.

   b. The static and residual pressures shall be recorded on the contractor’s material and test certificate.

3. All control valves shall be fully closed and opened under system water pressure to ensure proper operation.

C. Backflow prevention assemblies:

1. The backflow prevention assembly shall be forward flow tested to ensure proper operation.

2. The minimum flow rate shall be the system demand, including hose stream where applicable.

3. Where the backflow prevention assembly is provided by others, the contractor shall verify all tests are complete prior to connecting to supply piping inside the building.

3.13 PLACING THE SYSTEM IN OPERATION

A. The contractor shall perform the following prior to requesting final approval of sprinkler systems:

1. Notify the authority having jurisdiction and the property owner or the property owner's authorized representative of the time and date testing will be performed.

2. Perform all required acceptance tests.

3. Complete and sign the appropriate contractor's material and test certificate(s).

4. Remove all caps and straps prior to placing the sprinkler system in service.

END OF SECTION

SECTION 21 20 00

STATIONARY FIRE PUMPS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
   1. Centrifugal pumps.
   2. Electric drives for pumps.
   3. Electric drive controllers and accessories.
   4. Pump accessories.
   5. Pressure maintenance (jockey) pumps.

1.2 REFERENCES

A. American National Standard Institute (ANSI):
   1. ANSI C62.1 – IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits.
   2. ANSI C62.11 – IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits.
   3. ANSI C62.41 – IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   4. ANSI 508 – Standard for Industrial Control Equipment.
   5. ANSI 1449 – Standard for Surge Protective Devices.

B. International Building Code with North Carolina Amendments:
   1. North Carolina Fire Prevention Code.
   2. North Carolina Plumbing Code.

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA MG-1 – Motors and Generators.

D. National Fire Protection Association (NFPA):
   1. NFPA 13 – Standard for the Installation of Sprinkler Systems.
   2. NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection.
   3. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
   4. NFPA 70 – National Electrical Code.
   5. NFPA 70E – Standard for Electrical Safety in the Workplace.
   6. NFPA 72 – National Fire Alarm and Signaling Code.

1.3 SUBMITTALS

A. Refer to specification section 21 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data for the following:
   1. Centrifugal pumps.
   2. Electric drives for pumps.
   3. Electric drive controllers and accessories.
   4. Pump accessories.
   5. Pressure maintenance (jockey) pumps.

C. Submit shop drawings in accordance with the following:
   1. Stationary fire pumps shall be selected based on the conditions under which they are to be installed and used.

2. The pump manufacturer or its authorized representative shall be given complete information concerning the liquid and power supply characteristics.
3. A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and liquid supply connections shall be prepared for approval.
4. Plans shall be drawn to an indicated scale on sheets of a uniform size, and shall indicate, as a minimum, the items from the following list that pertain to the design of the systems:
    a. Name of owner and occupant.
    b. Location, including street address.
    c. Point of compass.
    d. Name and address of installing contractor.
    e. Pump make and model number.
    f. Pump rating, in gpm at psi and with rpm.
    g. Suction main size, length, location, weight, type of material, and point of connection to water supply, as well as size and type of valves, valve indicators, regulators, meters, and valve pits, and depth to top of pipe below grade.
    h. Water supply capacity information including the following:
        1) Location and elevation of static and residual test gauge with relation to the riser reference point.
        2) Flow location.
        3) Static pressure, in psi.
        4) Residual pressure, in psi.
        5) Flow, in gpm.
        6) Date.
        7) Time.
        8) Name of person who conducted the test or supplied the information.
        9) Other sources of water supply, with pressure or elevation.
    i. Pump driver details including manufacturer, horsepower, voltage, or fuel system details.
    j. Controller manufacturer, type, and rating.
    k. Suction and discharge pipe, fittings, and valve types.
    l. Test connection piping and valves.
    m. Flow meter details.
    n. Jockey pump and controller arrangement, including sensing line details.
5. Each pump, driver, controlling equipment, power supply and arrangement, and liquid supply shall be approved by the authority having jurisdiction for the specific field conditions encountered.

D. Submittals shall be prepared by a qualified design professional currently employed by the contractor as follows:
1. Plans shall be prepared under the direct supervision of either a licensed professional engineer registered in the state of North Carolina or a NICET level III technician certified in water-based suppression systems.
2. The design professional shall be on good standing with the associated accreditation board and shall have paid all required board fees, performed all necessary renewal procedures, and paid any required state taxes or licensing fees associated with maintaining accreditation.
3. The design professional shall also affix their individual certification mark, indicating registration/certification number and their name as it is recorded with

the associated accreditation board, and shall provide a unique signature to each sheet of the submittal.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 21 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data, manufacturer's warranties, and operation and maintenance instructions for the following:
   1. Centrifugal pumps.
   2. Electric drives for pumps.
   3. Electric drive controllers and accessories.
   4. Pump accessories.
   5. Pressure maintenance (jockey) pumps.

C. One (1) set of record drawings shall be provided to the building owner.

D. One (1) copy of the completed test report shall be provided to the building owner.

E. One (1) set of instruction manuals for all major components of the fire pump system shall be supplied by the manufacturer of each major component.

F. The manual shall contain the following:
   1. A detailed explanation of the operation of the component.
   2. Instructions for routine maintenance.
   3. Detailed instructions concerning repairs.
   4. Parts list and parts identification.
   5. Schematic electrical drawings of controller, transfer switch, and fire pump control panels.
   6. List of recommended spare parts and lubricants.

G. Any special tools and testing devices required for routine maintenance shall be available for inspection by the authority having jurisdiction at the time of the field acceptance test. One (1) of each tool and testing device shall be provided to the owner at project closeout.

1.5 GENERAL SYSTEM REQUIREMENTS

A. Fire pump unit performance:
   1. The fire pump unit, consisting of a pump, driver, and controller, shall perform in compliance with NFPA 20 as an entire unit when installed or when components have been replaced.
   2. The complete fire pump unit shall be field acceptance tested for proper performance in accordance with NFPA 20.

B. Certified shop test:
   1. Certified shop test curves showing head capacity and brake horsepower of the pump shall be furnished by the manufacturer to the purchaser.
   2. The purchaser shall furnish this data to the authority having jurisdiction.

C. Liquid supplies:
   1. Reliability:
      a. The adequacy and dependability of the water source are of primary importance and shall be fully determined, with due allowance for its reliability in the future.
      b. Where a water flow test is used to determine the adequacy of the attached water supply, the test shall have been completed not more than

twelve (12) months prior to the submission of working plans, unless otherwise permitted by the authority having jurisdiction.

2. Head:
   a. The head available from a water supply shall be figured on the basis of a flow of one-hundred-fifty (150) percent of rated capacity of the fire pump.
   b. Where the water supply cannot provide a flow of one-hundred-fifty (150) percent of the rated flow of the pump but the water supply can provide the greater of one-hundred (100) percent of the rated flow or the flow demand of the fire protection system(s), the head available from the water supply shall be permitted to be calculated on the basis of the maximum flow available.
   c. This head shall be as indicated by a flow test.

D. Pumps, drivers, and controllers:
1. Fire pumps shall be dedicated to and listed for fire protection service.
2. A pump shall not be equipped with more than one driver.
3. Each fire pump shall have its own dedicated driver unless otherwise permitted by NFPA 20.8.6.3.1.
4. Each driver shall have its own dedicated controller.
5. The driver shall be selected to provide the required power to operate the pump at rated speed and maximum pump load under any flow condition.

E. Pressure actuated controller pressure sensing lines:
1. For all pump installations, including jockey pumps, each controller shall have its own individual pressure sensing line.
2. The pressure sensing line connection for each pump, including jockey pumps, shall be made between that pump's discharge check valve and discharge isolation valve.
3. The pressure sensing line shall be brass, rigid copper pipes type K, L, or M, or series 3000 stainless steel pipe or tube, and the fittings shall be of one-half (0.5) inch nominal size.
4. Check valves or ground-face unions:
   a. There shall be two (2) check valves installed in the pressure sensing line at least five (5) feet apart with a nominal 0.09375-inch hole drilled in the clapper to serve as dampening.
   b. Where the water is clean, ground-face unions with noncorrosive diaphragms drilled with a nominal 0.09375-inch orifice shall be permitted in place of the check valves.
   c. There shall be two (2) inspection test valves attached to the pressure sensing line that shall consist of a tee, a valve, a second tee with the branch plugged, and a second valve.
5. There shall be no shutoff valve in the pressure sensing line.
6. Pressure switch actuation at the low adjustment setting shall initiate the pump starting sequence if the pump is not already in operation.

PART 2 PRODUCTS

2.1 CENTRIFUGAL PUMPS

A. Maximum pressure:
1. The net pump shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, shall not exceed the pressure for which the system components are rated.

2. Pressure relief valves and regulating devices in the fire pump installation shall not be used as means to meet this requirement.
3. Variable speed pressure limiting control:
   a. Variable speed pressure limiting control drivers, as defined by NFPA 20, shall be acceptable to limit system pressure.
4. The set pressure plus the maximum pressure variance of the variable speed pressure limiting control systems during variable speed operation and adjusted for elevation shall not exceed the pressure rating of any system component.

B. Capacities:
1. A centrifugal fire pump for fire protection shall be selected so that the greatest single demand for any fire protection system connected to the pump is less than or equal to one-hundred-fifty (150) percent of the rated capacity of the pump.
2. Centrifugal fire pumps shall have one of the rated capacities in gpm as identified in Table 4.8.2 of NFPA 20 and shall be rated at net pressures of forty (40) psi or more.

C. General
1. Types:
   a. Centrifugal pumps shall be of the overhung impeller design and the impeller between bearings design.
   b. The overhung impeller design shall be close coupled or separately coupled single- or two-stage end-suction-type or in-line-type pumps.
   c. The impeller between bearings design shall be separately coupled single-stage or multistage axial (horizontal) split-case-type or radial (vertical) split-case-type pumps.
2. Centrifugal pumps shall not be used where a static suction lift is required.

D. Factory and field performance:
1. Pumps shall furnish not less than one-hundred-fifty (150) percent of rated capacity at not less than sixty-five (65) percent of total rated head.
2. The shutoff head shall not exceed one-hundred-forty (140) percent of rated head for any type pump.

2.2 ELECTRIC DRIVES FOR PUMPS

A. General:
1. All electrical equipment and installation methods shall comply with NFPA 70.
2. All power supplies shall be located and arranged to protect against damage by fire from within the premises and exposing hazards.
3. All power supplies shall have the capacity to run the fire pump on a continuous basis.
4. All power supplies shall comply with the following voltage drop requirements:
   a. Unless one of the following requirements are met, the voltage at the controller line terminals shall not drop more than fifteen (15) percent below normal (controller-rated voltage) under motor-starting conditions.
      1) This requirement shall not apply to emergency-run mechanical starting.
      2) This requirement shall not apply to the bypass mode of a variable speed pressure-limiting control, provided a successful start can be demonstrated on the generator.
   b. The voltage at the contactor(s) load terminals to which the motor is connected shall not drop more than five (5) percent below the voltage rating of the motor when the motor is operating at one-hundred-fifteen (115) percent of the full-load current rating of the motor.

1) Wiring from the controller(s) to the pump motor shall be in rigid metal conduit, intermediate metal conduit, electrical metal tubing, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic Type LFNC-B, listed Type MC cable with an impervious covering, or Type MI cable.
2) Electrical connections at motor terminal boxes shall be made with a listed means of connection.
3) Twist-on insulation-piercing type and soldered wire connectors shall not be permitted to be used for this purpose.

5. Phase converters shall not be used to supply power to a fire pump.
6. Interruption:
   a. No ground fault interruption means shall be installed in any fire pump control or power circuit.
   b. No arc fault interruption means shall be installed in any fire pump control or power circuit.

B. Motors:

1. General:
   a. All motors shall comply with NEMA MG-1, shall be marked as complying with NEMA Design B standards, and shall by specifically listed for fire pump service.
   b. Part-winding motors shall have a fifty-fifty (50-50) winding ratio in order to have equal currents in both windings while running at nominal speed.
   c. The corresponding values of locked rotor current for motors rated at other voltages shall be determined by multiplying the values shown by the ratio of 460V to the rated voltage shown in Table 9.5.1.1 of NFPA 20.
   d. Motors used with variable speed controllers:
      1) Motors shall meet the applicable requirements of NEMA MG-1, Part 30 or 31.
      2) Motors shall be listed, suitable, and marked for inverter duty.
   e. Code letters of motors for all other voltages shall conform to those shown for 460V in Table 9.5.1.1 of NFPA 20.
   f. All motors shall be rated for continuous duty.
   g. Electric motor-induced transients shall be coordinated with the electrical characteristics of the electric drive controller to prevent nuisance tripping of motor controller protective devices.
2. Current limits:
   a. The motor capacity in horsepower shall be such that the maximum motor current in any phase under any condition of pump load and voltage unbalance shall not exceed the motor-rated full-load current multiplied by the service factor.
   b. The following shall apply for the service factor:
      1) The maximum service factor at which a motor shall be used is 1.15.
      2) Where the motor is used with a variable speed pressure limiting controller, the service factor shall not be used.
   c. These service factors shall be in accordance with NEMA MG-1.
   d. General-purpose (open and drip proof) motors, totally enclosed fan cooled (TEFC) motors, and totally enclosed nonventilated (TENV) motors shall not have a service factor larger than 1.15.
3. Marking:

a. Marking of motor terminals shall be in accordance with NEMA MG-1, Part 2.
b. A motor terminal connecting diagram for multiple lead motors shall be furnished by the motor manufacturer.

2.3 ELECTRIC DRIVE CONTROLLERS AND ACCESSORIES

A. General:
1. Performance and testing:
a. All controllers and transfer switches shall be specifically listed for electric motor-driven fire pump service.
b. Marking:
1) The controller and transfer switch shall be suitable for the available short-circuit current at the line terminals of the controller and transfer switch.
2) The controller and transfer switch shall be marked “Suitable for use on a circuit capable of delivering not more than ___ amperes RMS symmetrical at ___ volts ac,” or “___ amperes RMS symmetrical at ___ volts ac short-circuit current rating,” or equivalent, where the blank spaces shown shall have appropriate values filled in for each installation.
c. All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.
1) Controllers shipped in sections shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.
2) Such controllers shall be reassembled in the field, and the proper assembly shall be verified by the manufacturer or designated representative.
d. All controllers and transfer switches shall be listed as “suitable for use as service equipment” where so used.
e. Additional marking:
1) All controllers shall be marked “Electric Fire Pump Controller” and shall show plainly the name of the manufacturer, identifying designation, maximum operating pressure, enclosure type designation, and complete electrical rating.
f. It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a manufacturer’s representative when needed for service and adjustments of the equipment during the installation, testing, and warranty periods.
g. The controller shall be in a fully functional state within ten (10) seconds upon application of ac power.
2. All electrical control equipment design shall comply with NFPA 70, and other applicable documents.

B. Construction:
1. All equipment shall be suitable for use in locations subject to a moderate degree of moisture, such as a damp basement.
2. All equipment shall be mounted in a substantial manner on a single noncombustible supporting structure.
3. Enclosures:
a. The structure or panel shall be securely mounted in, as a minimum, a NEMA Type 2, drip proof enclosure(s) or an enclosure(s) with an ingress protection rating of IP31.

b. The enclosure(s) shall be grounded in accordance with NFPA 70.

4. Connections and wiring:
   a. All busbars and connections shall be readily accessible for maintenance work after installation of the controller.
   b. All busbars and connections shall be arranged so that disconnection of the external circuit conductors will not be required.
   c. Means shall be provided on the exterior of the controller to read all line currents and all line voltages with an accuracy within five (5) percent of motor nameplate voltage and current.
   d. Continuous-duty basis:
      1) Busbars and other wiring elements of the controller shall be designed on a continuous-duty basis.
      2) This requirement shall not apply to conductors that are in a circuit only during the motor starting period, which shall be permitted to be designed accordingly.
   e. Field connections:
      1) A fire pump controller shall not be used as a junction box to supply other equipment.
      2) No undervoltage, phase loss, frequency sensitive, or other device(s) shall be field installed that automatically or manually prohibits electrical actuation of the motor contactor.
   f. Electrical supply conductors for pressure maintenance (jockey) pump(s) shall not be connected to the fire pump controller.
5. Protection of control circuits:
   a. Circuits that are necessary for proper operation of the controller shall not have overcurrent protection devices connected in them.
   b. The secondary of the transformer and control circuitry shall be permitted to be ungrounded except as required for low-voltage control circuits.
6. All switching equipment for manual use in connecting or disconnecting or starting or stopping the motor shall be externally operable.
7. Electrical diagrams and instructions:
   a. An electrical schematic diagram shall be provided and permanently attached to the inside of the controller enclosure.
   b. All the field wiring terminals shall be plainly marked to correspond with the field connection diagram furnished.
   c. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.
   d. The installation instructions of the manufacturer of the fire pump controller shall be followed.
8. Marking:
   a. Each motor control device and each switch and circuit breaker shall be marked to plainly indicate the name of the manufacturer, the designated identifying number, and the electrical rating in volts, horsepower, amperes, frequency, phases, and so forth, as appropriate.
   b. The markings shall be so located as to be visible after installation.

C. Components:
1. Voltage surge arrester:
   a. A voltage surge arrester complying with ANSI C62.1 or ANSI C62.11 shall be installed from each phase to ground.
   b. The surge arrester shall be rated to suppress voltage surges above line voltage.

c. The above requirements shall not apply where the controller can withstand without damage a ten (10) kV impulse in accordance with ANSI C62.41, or where the controller is listed to withstand surges and impulses in accordance with ANSI 1449.

2. Isolating switch:
   a. General:
      1) The isolating switch shall be a manually operable motor circuit switch or a molded case switch having a horsepower rating equal to or greater than the motor horsepower.
      2) A molded case switch having an ampere rating not less than one-hundred-fifteen (115) percent of the motor rated full-load current and also suitable for interrupting the motor locked rotor current shall be permitted.
      3) A molded case isolating switch shall be permitted to have self-protecting instantaneous short-circuit overcurrent protection, provided that this switch does not trip unless the circuit breaker in the same controller trips.
   b. The isolating switch shall be externally operable.
   c. The ampere rating of the isolating switch shall be at least one-hundred-fifteen (115) percent of the full-load current rating of the motor.
   d. Warning:
      1) The following warning shall appear on or immediately adjacent to the isolating switch, "WARNING – DO NOT OPEN OR CLOSE THIS SWITCH WHILE THE CIRCUIT BREAKER (DISCONNECTING MEANS) IS IN CLOSED POSITION."
      2) The above requirement shall not apply where the following requirements are met:
         a) Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed, the warning label shall be permitted to be replaced with an instruction label that directs the order of operation.
         b) This label shall be permitted to be part of the electrical diagrams and instructions.
   e. Operating handle:
      1) The isolating switch operating handle shall be provided with a spring latch that shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit opening or closing of the switch.
      2) The above requirements shall not apply where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed with the circuit breaker is closed.

3. Circuit breaker (disconnecting means):
   a. The motor branch circuit shall be protected by a circuit breaker that shall be connected directly to the load side of the isolating switch and shall have one pole for each ungrounded circuit conductor.
   b. The circuit breaker shall have the following mechanical characteristics:
      1) It shall be externally operable.
      2) It shall trip free of the handle.
      3) A nameplate with the legend "Circuit Breaker – Disconnecting means" in letters not less than three-eighths (0.375) inch high

shall be located on the outside of the controller enclosure adjacent to the means for operating the circuit breaker.

c. Electrical characteristics:
   1) The circuit breaker shall have the following characteristics:
      a) A continuous current rating of not less than one-hundred-fifteen (115) percent of the rated full-load current of the motor.
      b) Overcurrent-sensing elements of the nonthermal type.
      c) Instantaneous short-circuit overcurrent protection.
      d) An adequate interrupting rating to provide the suitability rating of the controller.
      e) Capability of allowing normal and emergency starting and running of the motor without tripping.
      f) An instantaneous trip setting of not more than twenty (20) times the full-load current.
      g) The circuit breaker shall not trip when starting a motor from rest in the across-the-line (direct-on-line) mode, whether or not the controller is of the reduced inrush starting type.
      h) The circuit breaker shall not trip when power is interrupted from a running pump, or if the pump is restarted in less than three (3) seconds after being shut down. If a control circuit preventing a restart within three (3) seconds is provided, this requirement shall not apply.
   2) Current limiters, where integral parts of the circuit breaker, shall be permitted to be used to obtain the required interrupting rating, provided all the following requirements are met:
      a) The breaker shall accept current limiters of only one rating.
      b) The current limiters shall hold three hundred (300) percent of full-load motor current for a minimum of thirty (30) minutes.
      c) The current limiters, where installed in the breaker, shall not open at locked rotor current.
      d) A spare set of current limiters of correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

4. The only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor shall be located within the fire pump controller and shall possess the following characteristics:
   a. For a squirrel-cage or wound-rotor induction motor, the device shall be of the time-delay type having tripping times as follows:
      1) Between eight (8) seconds and twenty (20) seconds at locked rotor current.
      2) Three (3) minutes at a minimum of three hundred (300) percent of motor full-load current.
   b. For a direct-current motor, the device shall be as follows:
      1) Of the instantaneous type.
      2) Calibrated and set at a minimum of four hundred (400) percent of motor full-load current.
   c. There shall be visual means or marking clearly indicated on the device that proper settings have been made.

d. It shall be possible to reset the device for operation immediately after tripping, with the tripping characteristics thereafter remaining unchanged.
e. Tripping shall be accomplished by opening the circuit breaker, which shall be of the external manual reset type.

5. Motor starting circuitry:
a. The motor contactor shall be horsepower rated and shall be of the magnetic type with a contact in each ungrounded connector.
1) Running contactors shall be sized for both the locked rotor currents and the continuous running currents encountered.
2) Starting contactors shall be sized for both the locked rotor current and the acceleration (starting) encountered.
b. Timed acceleration:
1) For electrical operation of reduced-voltage controllers, timed automatic acceleration of the motor shall be provided.
2) The period of motor acceleration shall not exceed ten (10) seconds.
c. Starting resistors shall be designed to permit one five (5) second starting operation every eighty (80) seconds for a period of not less than one (1) hour.
d. Starting reactors and autotransformers:
1) Starting reactors and autotransformers shall comply with the requirements of ANSI 508, Table 92.1.
e. Soft start units:
1) Soft start units shall be horsepower rated or specifically designed for the service.
2) The bypass contactor shall comply with the requirements for motor contactors.
3) Soft start units shall comply with the duty cycle requirements of starting reactors and autotransformers.
f. Single-phase sensors in controller:
1) Sensors shall be permitted to prevent a three-phase motor from starting under single-phase condition.
2) Such sensors shall not cause disconnection of the motor if it is running at the time of single-phase occurrence.
3) Such sensors shall be monitored to provide a local visible signal in the event of malfunction of the sensors.
g. No ground fault protection (tripping) shall be allowed.
h. A ground fault alarm shall be permitted.

6. Signal devices on controller:
a. Power available visible indicator:
1) A visible indicator shall monitor the availability of power in all phases at the line terminals of the motor contactor or of the bypass contactor, if provided.
2) If the visible indicator is a pilot lamp, it shall be accessible for replacement.
3) When power is supplied from multiple power sources, monitoring of each power source for phase loss shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.
b. Phase reversal:

1) Phase reversal of the power source to which the line terminals of the motor contactor are connected shall be indicated by a visible indicator.
2) When power is supplied from multiple power sources, monitoring of each power source for phase reversal shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sourced are monitored.

7. Fire pump alarm and signal devices remote from controller:
   a. Where the pump room is not constantly attended, audible of visible signals powered by a source not exceeding one-hundred-twenty-five (125) volts shall be provided at a point of constant attendance.
   b. Those fire pump alarms and signals shall indicate the following:
      1) The signal shall actuate whenever the controller has operated into a motor-running condition.
         a) This signal shall be energized by a separate reliable supervised power source of from the pump motor power, reduced to not more than one-hundred-twenty-five (125) volts.
      2) Loss of phase:
         a) The fire pump alarm shall actuate whenever any phase at the line terminals of the motor contactor is lost.
         b) All phases shall be monitored. Such monitoring shall detect loss of phase whenever the motor is running or at rest.
         c) When power is supplied from multiple power sources, monitoring of each power source for phase loss shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.
      3) The fire pump alarm shall actuate whenever the three-phase power at the line terminals of the motor contactor is reversed.
         a) The fire pump alarm circuit shall be energized by a separate reliable supervised power source or from the pump motor power, reduced to not more than one-hundred-twenty-five (125) volts.
      4) Controller connected to alternate source:
         a) Where two (2) sources of power are supplied, this signal shall indicate whenever the alternate source is the source supplying power to the controller.
         b) This signal shall be energized be a separate reliable supervised power source, reduced to not more than one-hundred-twenty-five (125) volts.
8. Controllers shall be equipped with contacts (open or closed) to operate alarm signal devices and when a controller is equipped with a transfer switch.

D. Starting and control:
   1. Automatic and nonautomatic:
      a. An automatic controller shall be self-acting to start, run, and protect a motor.
      b. An automatic controller shall be arranged to start the driver upon actuation of a pressure switch or non-pressure switch.
      c. An automatic controller shall be operable also as a nonautomatic controller.

d. A nonautomatic controller shall be actuated by manually initiated electrical means and by manually initiated means.

2. Automatic controller:

a. Water pressure control:

1) Pressure-actuated switches

a) There shall be provided a pressure-actuated switch or electronic pressure sensor having adjustable high- and low-calibrated setpoints as part of the controller.

2) There shall be no pressure snubber or restrictive orifice employed within the pressure switch or pressure responsive means.

3) There shall be no valve or other restrictions within the controller ahead of the pressure switch or pressure responsive means.

4) This switch shall be responsive to water pressure in the fire protection system.

5) The pressure sensing element of the switch shall be capable of withstanding a momentary surge pressure of four hundred (400) psi or one-hundred-thirty-three (133) percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

6) Suitable provision shall be made for relieving pressure to the pressure-actuated switch to allow testing of the operation of the controller and the pumping unit.

7) Water pressure control shall be in accordance with the following:

a) Pressure switch actuation at the low adjustment setting shall initiate the pump starting sequence (if pump is not already in operation).

b) A pressure recording device shall record the pressure in each fire pump controller pressure-sensing line at the input to the controller.

c) The pressure recorder shall be listed as part of the controller or shall be a separately listed unit installed to sense the pressure at the input of the controller.

d) The recorder shall be capable of operating for at least seven (7) days without being reset or rewound.

e) The pressure sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least four hundred (400) psi or one-hundred-thirty-three (133) percent of fire pump controller operating pressure, whichever is greater, without losing its accuracy.

f) For variable speed pressure limiting control, a one-half (0.5) inch nominal size inside diameter pressure line shall be connected to the discharge piping at a point recommended by the variable speed control manufacturer. The connection shall be between the discharge check valve and the discharge control valve.

b. External circuits connected to controllers:

1) External control circuits that extend outside the fire pump room shall be arranged so that failure of any external circuit (open, ground-fault, or short circuit) shall not prevent operation of pump(s) from all other internal or external means.

2) Breakage, disconnecting, shorting of the wires, ground fault, or loss of power to these circuits shall be permitted to cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits.
3) All control conductors within the fire pump room that are not fault tolerant shall be protected from mechanical injury.

3. Nonautomatic controller.
   a. Manual electric control at controller:
      1) There shall be a manually operated switch on the control panel so arranged that, when the motor is started manually, its operation cannot be affected by the pressure-actuated switch.
      2) The arrangement shall also provide that the unit will remain in operation until manually shut down.
   b. Emergency-run mechanical control at controller:
      1) The controller shall be equipped with an emergency-run handle or lever that operates to mechanically close the motor-circuit switching mechanism.
         a) This handle or lever shall provide for nonautomatic continuous running operation of the motor(s) independent of any electric control circuits, magnets, or equivalent devices and independent of the pressure-activated control switch.
         b) Means shall be incorporated for mechanically latching or holding the handle or lever for manual operation in the actuated position.
         c) The mechanical latching shall be designed to be automatic or manual.
      2) The handle or lever shall be arranged to move in one direction only from the off position to the final position.
      3) The motor starter shall return automatically to the off position in case the operator releases the starter handle or lever in any position but the full running position.
      4) The operating handle shall be marked or labeled as to its function and operation.
4. Shutdown shall be accomplished by one of the following methods:
   a. Manual shutdown shall be accomplished by operation of a pushbutton on the outside of the controller enclosure that, in the case of automatic controllers, shall return the controller to the fully automatic position.
   b. Where provided, automatic shutdown after automatic start shall comply with the following:
      1) Automatic shutdown shall be permitted only where the controller is arranged for automatic shutdown after all starting and running causes have returned to normal.
      2) A running period timer set for at least ten (10) minutes running time shall be permitted to commence at initial operation.
      3) Automatic shutdown shall not be permitted where the pump constitutes the sole supply of a fire sprinkler or standpipe system or where the authority having jurisdiction has required manual shutdown.

E. Controllers with variable speed pressure limiting control or variable speed suction limiting control:
   1. Control equipment:

a. Controllers with variable speed pressure limiting control or variable speed suction limiting control shall be listed for fire service.
b. The variable speed pressure limiting control or variable speed suction limiting control shall have a horsepower rating at least equal to the motor horsepower, or where rated in amperes, shall have an ampere rating of not less than the motor full-load current.

2. The controller shall be additionally marked with the maximum ambient temperature rating.
3. Bypass operation:
   a. Upon failure of the variable speed pressure limiting control to keep the system pressure at or above the set pressure of the variable speed pressure limiting control system, the controller shall bypass and isolate the variable speed pressure limiting control system and operate the pump at rated speed.
      1) If the system pressure remains below the set pressure for more than fifteen (15) seconds, the bypass operation shall occur.
      2) If the variable speed drive indicates that it is not operational within five (5) seconds, the bypass operation shall occur.
      3) Means shall be provided to prevent higher than normal in-rush currents when transferring the fire pump motor from the variable speed mode to the bypass mode.
   b. When the variable speed pressure limiting control is bypassed, the unit shall remain bypassed until manually restored.
   c. The bypass contactors shall be operable using the emergency-run handle or lever.
   d. When the variable speed pressure limiting control is bypassed, automatic shutdown of the controller shall be as permitted by section 10.5.4.2 of NFPA 20.
   e. When the manual selection means is used to initiate a switchover from variable speed to bypass mode, if the pump is running in the variable speed mode and none of the conditions that require the controller to initiate the bypass operation exist, the controller shall be arranged to provide a restart delay to allow the motor to be de-energized before it is re-energized in the bypass mode.

2.4 PUMP ACCESSORIES

A. Nameplate:
   1. Pumps shall be provided with a nameplate.
   2. The name plate shall be made of and attached using corrosion resistant material.

B. Pressure gauges:
   1. Discharge:
      a. A pressure gauge having a dial not less than three-and-one-half (3.5) inches in diameter shall be connected near the discharge casting with a nominal one-quarter (0.25) inch gauge valve.
      b. The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than two-hundred (200) psi.
      c. The face of the dial shall read in psi with the manufacturer’s standard graduations.
   2. Suction:
      a. A pressure gauge having a dial not less than three-and-one-half (3.5) inches in diameter shall be connected to the suction pipe with a nominal one-quarter (0.25) inch gauge valve.

1) Where the minimum pump suction pressure is below twenty (20) psi under any flow condition, the suction gauge shall be a compound pressure and vacuum gauge.

b. The face of the dial shall read in psi for the suction range.

c. The gauge shall have a pressure range two (2) times the rated maximum suction pressure of the pump.

C. Suction pipe and fittings:

1. Components:

a. The suction components shall consist of all pipe, valves, and fittings from the pump suction flange to the connection to the public or private water service main, storage tank, or reservoir, and so forth, that feeds water to the pump.

2. Suction size:

a. The size of the suction pipe for a single pump or the suction header pipe for multiple pumps shall be such that, with all pumps operating at maximum flow, the gauge pressure at the pump suction flanges shall be zero (0) psi or higher.

b. This requirement shall not apply where the supply is a suction tank with its base at or above the same elevation as the pump, and the gauge pressure at the pump suction flange shall be permitted to drop to negative three (3) psi with the lowest water level after the maximum system demand and duration have been supplied.

c. The size of that portion of the suction pipe located within ten (10) pipe diameters upstream of the pump suction flange shall not be less than that shown in Table 4.26(a) of NFPA 20.

3. Pumps with bypass:

a. Where the suction supply pressure is of sufficient pressure to be of material value without the pump, the pump shall be installed with a bypass.

b. The size of the bypass shall be at least as large as the pipe size required for discharge pipe as shown in Table 4.26(1) of NFPA 20.

4. Valves:

a. A listed outside screw and yoke (OS&Y) gate valve shall be installed in the suction pipe.

b. No control valve other than a listed OS&Y valve and those required by backflow prevention devices shall be installed in the suction pipe within fifty (50) feet of the pump suction flange.

5. Installation:

a. Suction pipe shall be laid carefully to avoid air leaks and air pockets, either of which can seriously affect the operation of the pump.

b. Elbows and tees:

1) Elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft shall not be permitted.

2) This requirement shall not apply to elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft where the distance between the flanges of the pump suction intake and the elbow and tee is greater than ten (10) times the suction pipe diameter.

3) Elbows and tees with a centerline plan perpendicular to the horizontal split-case pump shaft shall be permitted at any location in the pump suction intake.

c. Where the suction pipe and pump suction flange are not of the same size, they shall be connected with an eccentric tapered reducer or increaser installed is such a way as to avoid air pockets.
d. Where the pump and its suction supply are on separate foundations with rigid interconnecting pipe, the pipe shall be provided with strain relief.

6. Devices in suction piping:
   a. No device or assembly that will stop, restrict the starting of, or restrict the discharge of a fire pump or pump driver shall be installed in the suction piping.
   b. The following devices shall be permitted in the suction piping where the following requirements are met:
      1) Check valves and backflow prevention devices and assemblies shall be permitted where required by other NFPA standards or the authority having jurisdiction.
      2) Where the authority having jurisdiction requires positive pressure to be maintained on the suction piping, a pressure sensing line for a low suction pressure control, specifically listed for fire pump service, shall be permitted to be connected to the suction piping.
      3) Devices shall be permitted to be installed in the suction supply piping or stored water supply and arranged to activate a signal if the pump suction pressure or water level falls below a predetermined minimum.
      4) Suction strainers shall be permitted to be installed in the suction piping where required by NFPA 20.
      5) Other devices specifically permitted or required by NFPA 20 shall be permitted.

D. Discharge pipe and fittings:
1. The discharge components shall consist of pipe, valves, and fittings extending from the pump discharge flange to the system side of the discharge valve.
2. The pressure rating of the discharge components shall be adequate for the maximum total discharge head with the pump operating at shutoff and rated speed but shall not be less than the rating of the fire protection systems.
3. Steel pipe with flanges, screwed joints, or mechanical grooved joints shall be used aboveground.
4. All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 13.
5. The size of the pump discharge and fittings shall not be less that shown in Table 4.26(a) of NFPA 20.
6. A listed check valve or backflow preventer shall be installed in the pump discharge assembly.
7. A listed indicating gate or butterfly valve shall be installed on the fire protection system side of the pump discharge check valve.
8. Low suction pressure controls:
   a. Low suction throttling valves for pump drivers that are listed for fire pump service and that are suction pressure sensitive shall be permitted where the authority having jurisdiction requires positive pressure to be maintained on the suction piping.
   b. When a low suction throttling valve is used, it shall be installed according to manufacturer’s recommendations in the piping between the pump and the discharge check valve.

c. The size of the low suction throttling valve shall not be less than that given for discharge piping in Table 4.26(a) of NFPA 20.
d. The friction loss through a low suction throttling valve in the fully open position shall be considered in the design of the fire protection system.
e. System design shall be such that the low suction throttling valve is in the fully open position at system design point.

9. No pressure regulating devices shall be installed in the discharge pipe except as permitted by NFPA 20.

E. Valve supervision:
1. Where provided, the suction valve, discharge valve, bypass valves, and isolation valves on the backflow prevention device or assembly shall be supervised open by one of the following methods:
a. Central station, proprietary, or remote station signaling service.
b. Local signaling service that will cause the sounding of an audible signal at a constantly attended point.
c. Locking valves open.
d. Sealing of valves and approved weekly recorded inspection where valves are located within fenced enclosures under the control of the owner.
2. Control valves located in the pipeline to the hose valve header shall be supervised closed by one of the methods for supervised open valves.

F. Water flow test devices:
1. General:
a. A fire pump installation shall be arranged to allow the test of the pump at its rated conditions as well as the suction supply at the maximum flow available from the fire pump.
b. Where water usage or discharge is not permitted for the duration of the field acceptance test, the outlet shall be used to test the pump and suction supply and determine that the system is operating in accordance with the design.
c. The flow shall continue until the flow has stabilized.
d. Where a test header is installed, it shall be installed on an exterior wall or in another location outside the pump room that allows for water discharge during testing.
2. Meters and testing devices:
a. Metering devices or fixed nozzles for pump testing shall be listed.
b. Metering devices or fixed nozzles shall be capable of water flow of not less than one-hundred-seventy-five (175) percent of rated pump capacity.
c. All the meter system piping shall be permitted to be sized hydraulically but shall not be smaller than as specified by the meter manufacturer.
d. If the meter system piping is not sized hydraulically, then all of the meter system piping shall be sized as specified by the meter manufacturer but not less than the meter device sizes shown in Table 4.26(a) of NFPA 20.
e. For nonhydraulically sized piping, the minimum size meter for a given pump capacity shall be permitted to be used where the meter system piping does not exceed one hundred (100) feet equivalent length.
f. The primary element shall be suitable for the pipe size and pump rating.
g. The readout instrument shall be sized for the pump rated capacity.
h. When discharging back into a tank, the discharge nozzle(s) or pipe shall be located at a point as far from the pump suction as is necessary to prevent the pump from drafting air introduced by the discharge of test water into the tank.

i. Where a metering device is installed in a loop arrangement for fire pump flow testing, an alternate means of measuring flow shall be provided.
   1) The alternate means of measuring flow shall be located downstream of and in series with the flow meter.
   2) The alternate means of measuring flow shall function for the range of flows necessary to conduct a full flow test.
   3) An appropriately sized test header shall be an acceptable alternate means of measuring flow.

3. Hose valves:
   a. General:
      1) Hoses valves shall be listed.
      2) The number and size of hose valves used for pump testing shall be as specified in Table 4.26(a) of NFPA 20.
      3) Where outlets are being utilized as a means to test the fire pump, one of the following methods shall be used:
         a) Hose valves mounted on a hose valve header.
         b) Wall hydrants, yard hydrants, or standpipe outlets of sufficient number and size to allow testing of the pump.
   b. Thread types shall comply with one of the following:
      1) Hose valve(s) shall have the NH standard external thread for the valve size specified, as stipulated in NFPA 1963.
      2) Where local fire department connections do not conform to NFPA 1963 and the connection is to be utilized as a wall hydrant, the authority having jurisdiction shall designate the threads to be used.
   c. Location:
      1) A listed indicating butterfly or gate valve shall be located in the pipeline to the hose valve header.
      2) A drain valve or automatic ball drip shall be located in the pipeline at a low point between the valve and the header.
      3) The butterfly or gate valve shall be at a point in the line close to the pump.
   d. The pipe size shall be in accordance with one of the following two methods:
      1) Where the pipe between the hose valve header and the connection to the pump discharge pipe is over fifteen (15) feet in length, the next larger pipe size shall be used.
      2) This pipe is permitted to be sized by hydraulic calculations based on a total flow of one-hundred-fifty (150) percent of rated pump capacity, including the following:
         a) This calculation shall include friction loss for the total length of pipe plus equivalent lengths of fittings, control valve, and hose valves, plus elevation loss, from the pump discharge flange to the hose valve outlets.
         b) The installation shall be proven by a test flowing the maximum water available.

2.5 PRESSURE MAINTENANCE (JOCKEY) PUMPS

A. Pressure maintenance pups shall not be required to be listed. Pressure maintenance pumps shall be approved.
   1. The pressure maintenance pump shall be sized to replenish the fire protection system pressure due to allowable leakage and normal drops in pressure.

B. Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate.

C. Pressure maintenance pumps shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

D. Piping and components for pressure maintenance pumps:
   1. Steel pipe shall be used for suction and discharge piping on pressure maintenance pumps, which includes package prefabricated systems.
   2. Valves and components for the pressure maintenance pump shall not be required to be listed.
   3. An isolation valve shall be installed on the suction side of the pressure maintenance pump to isolate the pump for repair.
   4. A check valve and isolation valve shall be installed on the discharge pipe.
   5. Indicating valves shall be installed in such places as needed to make the pump, check valve, and miscellaneous fittings accessible for repair.
   6. The pressure sensing line for the pressure maintenance pump shall be sized in accordance with the requirements for pressure actuated controller pressure sensing lines.
   7. The isolation valves serving the pressure maintenance pump shall not be required to be supervised.

E. The fire pump shall not be used as a pressure maintenance pump.

F. The controller for a pressure maintenance pump shall be listed but shall not be required to be listed for fire pump service.

G. The pressure maintenance pump shall not be required to have secondary or standby power.

PART 3 EXECUTION

3.1 SYSTEM FLUSHING AND HYDROSTATIC TEST

A. Flushing:
   1. Suction piping shall be flushed at a flow rate not less than indicated in Table 14.1.1.1 of NFPA 20 or at the hydraulically calculated water demand rate of the system, whichever is greater.
   2. Flushing shall occur prior to hydrostatic test.
   3. Where the maximum flow available from the water supply cannot provide the flow rate provided in Table 14.1.1.1 of NFPA 20, the flushing flow rate shall be the greater of one hundred (100) percent of the rated flow of the connected fire pump or the maximum flow demand of the fire protection system(s).
      a. This reduced flushing flow capacity shall constitute an acceptable test, provided that the flow rate exceeds the fire protection system design and flow rate.
   4. Flushing is to be performed, witnessed, and signed off before connection to the suction piping is completed.

B. Hydrostatic test:
   1. Suction and discharge piping shall be hydrostatically tested at not less than two hundred (200) psi or at fifty (50) psi in excess of the maximum pressure to be maintained in the system, whichever is greater.
   2. This pressure shall be maintained for two (2) hours.
   3. The installing contractor shall furnish a certificate for flushing and hydrostatic test prior to the start of the fire pump field acceptance tests.

4. These certificates shall be as shown in Figure A.14.1.3(a) and Figure A.14.1.3(b) of NFPA 20.

3.2 FIELD ACCEPTANCE TESTS

A. The pump manufacturer, the controller manufacturer, and the transfer switch manufacturer, or their factory-authorized representatives shall be present for the field acceptance tests.

B. The date, time, and location of the field acceptance tests shall be coordinated with the authority having jurisdiction.

C. All electrical wiring to the fire pump motor(s), including control inter-wiring, normal power supply, alternate power supply where provided, and jockey pump, shall be completed and checked by the electrical contractor prior to the initial startup and acceptance tests.

D. Certified pump curve:
   1. A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of the results of the field acceptance tests.
   2. At all flow conditions, the fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test equipment.

E. The actual unadjusted fire pump discharge flows and pressures installed shall meet or exceed the fire protection system's demand.

F. Field acceptance test procedures:
   1. The fire pump operation shall be in a manner as prescribed in NFPA 20.A.14.2.6 and as required by the manufacturer.
   2. Test equipment:
      a. Calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor-driven pumps, and speed.
      b. Calibrated test gauges shall be used and bear a label with the latest date of calibration.
         1) Gauges shall be calibrated a minimum of annually.
         2) Calibration of test gauges shall be maintained at an accuracy level of ± one (1) percent.
      c. Requirements for personal protective equipment and procedures in accordance with NFPA 70E shall be followed when working near energized electrical or rotating equipment.
   3. Fire pump flow testing:
      a. The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.
      b. Vibrations of the fire pump assembly shall not be of a magnitude to pose potential damage to any fire pump component.
      c. The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices.
      d. Where the maximum flow available from the water supply cannot provide a flow of one-hundred-fifty (150) percent of the rated flow of the pump, the fire pump shall be operated at the greater of one hundred (100) percent of rated flow or the maximum flow demand of the fire protection system(s) maximum allowable discharge to determine its acceptance.

1) This reduced capacity shall constitute an acceptable test, provided that the pump discharge exceeds the fire protection system design and flow rate.

4. Variable speed pressure limiting control:
   a. Pumps with variable speed pressure limiting control shall be tested at no-flow, twenty-five (25) percent, fifty (50) percent, seventy-five (75) percent, one hundred (100) percent, one-hundred-twenty-five (125) percent, and one-hundred-fifty (150) percent or rated load in the variable speed mode.
      1) They shall also be tested at minimum, rated, and peak loads, with the fire pump operating at rated speed.
   b. The fire protection system shall be isolated, and the pressure relief valve closed for the rated speed tests.
   c. The fire protection system shall be open, and the relief valve set for the variable speed tests.
5. Measurement procedure:
   a. The quantity of water discharging from the fire pump assembly shall be determined and stabilized.
   b. Immediately thereafter, the operating conditions of the fire pump and driver shall be measured.
   c. Electric motor-driven units:
      1) For electric motors operating at rated voltage and frequency, the ampere demand on each phase shall not exceed the product of the full-load ampere rating times the allowable service factor as stamped on the motor nameplate.
      2) The voltage at the motor contactor output lugs shall not vary more than five (5) percent below or ten (10) percent above rated voltage during the test.
6. The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.
7. For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply.

G. Controller acceptance tests:
1. Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure.
2. As a minimum, no fewer than six (6) automatic and six (6) manual operations shall be performed during the acceptance test.
3. An electric-driven fire pump shall be operated for a period of at least five (5) minutes at full speed during each of the fire pump flow test operations.
4. The automatic operation sequence of the controller shall start the pump from all provided starting features.
5. This sequence shall include pressure switches or remote starting signals.
6. The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with NFPA 20.
7. The fire pump shall be started once from each power service and fun for a minimum of five (5) minutes.
   a. Manual emergency operation shall be accomplished by manual actuation of the emergency handle to the fully latched position in a continuous motion. The handle shall be latched for the duration of this test run.

H. Alternate power supply:

1. On installations with an alternate source of power and an automatic transfer switch, loss of primary source shall be simulated, and transfer shall occur while the pump is operating at peak load.
2. Transfer from normal to alternate source and retransfer from alternate to normal source shall not cause opening of overcurrent protection devices in either line.
3. At least half of the manual and automatic operations of controller acceptance tests shall be performed with the fire pump connected to the alternate source.
4. If the alternate power source is a generator set required by NFPA 20.9.3.2, installation acceptance shall be in accordance with NFPA 110.

I. Both local and remote signals and fire pump alarm conditions shall be simulated to demonstrate satisfactory operation.

J. The fire pump shall be in operation for not less than one (1) hour total time during all the foregoing tests.

3.3 CENTRIFUGAL PUMP INSTALLATION

A. Fittings:
1. Where necessary, the following fittings for the pump shall be provided by the pump manufacturer or an authorized representative:
   a. Automatic air release valve.
   b. Circulation relief valve.
   c. Pressure gauges.
2. Where necessary, the following fittings shall be provided:
   a. Eccentric tapered reducer at suction inlet.
   b. Hose valve manifold with hose valves.
   c. Flow measuring device.
3. Automatic air release:
   a. Pumps that are automatically controlled shall be provided with a listed float-operated air release valve having a nominal one-half (0.5) inch minimum diameter discharged to atmosphere.
   b. This requirement shall not apply to overhung impeller type pumps with top centerline discharge or that are vertically mounted to naturally vent the air.

B. Foundation and setting:
1. Overhung impeller and impeller between bearings design pumps and driver shall be mounted on a common grouted base plate.
2. Pumps of the overhung impeller close coupled inline type shall be permitted to be mounted on a base attached to the pump mounting base plate.
3. The base plate shall be securely attached to a solid foundation in such a way that pump and driver shaft alignment is ensured.
4. The foundation shall be sufficiently substantial to form a permanent and rigid support for the base plate.
5. The base plate, with pump and driver mounted on it, shall be set level on the foundation.

C. Connection to driver and alignment
1. Coupling type:
   a. Separately coupled-type pumps with electric motor drivers shall be connected by a flexible coupling or flexible connecting shaft.
   b. All coupling types shall be listed for this service.

D. Pump and drivers on separately coupled-type pumps shall be aligned in accordance with the coupling and pump manufacturers' specifications and the *Hydraulic Institute Standards for Centrifugal, Rotary, and Reciprocating Pumps*.

3.4 ELECTRIC DRIVE INSTALLATION

A. Normal power:
   1. An electric motor-driven fire pump shall be provided with a normal source of power as a continually available source.
   2. The normal source of power and its routing shall be arranged in accordance with one of the following:
      a. Service connection dedicated to the fire pump installation.
      b. On-site power production facility connection dedicated to the fire pump installation.
      c. Dedicated feeder connection derived directly from the dedicated service to the fire pump installation.
      d. As a feeder connection where all of the following conditions are met:
         1) The protected facility is part of a multi-building campus-style arrangement.
         2) A backup source of power is provided from a source independent of the normal source of power.
         3) It is impractical to supply the normal power through previously listed means.
         4) The arrangement is acceptable to the authority having jurisdiction.
         5) The overcurrent protection device(s) in each disconnecting means is selectively coordinated with any other supply side overcurrent protection device(s).
      e. Dedicated transformer connection directly from the service meeting the requirements of NFPA 70.
   3. For fire pump installations not using the arrangement of section 21 20 00.2.2.B.2.d, for the normal source of power, no more than one (1) disconnecting means and associated overcurrent protection device shall be installed in the power supply to the fire pump controller.
      a. Where the disconnecting means is installed, the disconnecting means shall meet all the following:
         1) They shall be identified as being suitable for use as service equipment.
         2) They shall be lockable in the closed position.
         3) They shall be located remote from other building disconnecting means.
         4) They shall be located remote from other fire pump source disconnecting means.
         5) They shall be marked "Fire Pump Disconnecting Means" in letters that are no less than one (1) inch in height and that can be seen without opening enclosure doors or covers.
      b. Where the disconnecting means is installed, a placard shall be placed adjacent to the fire pump controller stating the location of this disconnecting means and the location of any key needed to unlock the disconnect.
      c. Where the disconnecting means is installed, the disconnect shall be supervised in the closed position by one of the following methods:
         1) Central station, proprietary, or remote station signal device.

2) Local signaling service that will cause the sounding of an audible signal at a constantly attended location.
3) Locking the disconnecting means in the closed position.
4) Sealing of disconnecting means and approved weekly recorded inspections where the disconnecting means are located within fenced enclosures or in buildings under the control of the owner.

d. Where the overcurrent protection is installed, the overcurrent protection device shall be rated to carry indefinitely the sum of the locked rotor current of the largest pump motor and the full-load current of all of the other pump motors and accessory equipment.
1) Alternatively, compliance with the previous paragraph shall be based on an assembly listed for fire pump service complying with the following:
a) The overcurrent protection device shall not open within two (2) minutes at six hundred (600) percent full-load current.
b) The overcurrent protection device shall not open with a restart transient of twenty-four (24) times the full-load current.
c) The overcurrent protection device shall not open within ten (10) minutes at three hundred (300) percent full load current.
d) Trip point for circuit breakers is not field adjustable.

B. Alternate power:
1. Where provided, the alternate supply shall be arranged so that the power to the fire pump is not disrupted when overhead lines are de-energized for fire department connections.

C. On-site standby generator systems:
1. Power sources:
a. On-site standby generator systems shall comply with the voltage drop requirements of NFPA 20, and shall meet the requirements of Level 1, Type 10, Class X systems of NFPA 110.
b. The generator shall run and continue to produce rated nameplate power without shutdown or derate for alarms and warnings or failed engine sensors, except for overspeed shutdown.
c. The generator fuel supply capacity shall be sufficient to provide eight (8) hours of fire pump operation at one hundred (100) percent of the rated pump capacity in addition to the supply required for other demands.
2. Automatic sequencing of the fire pumps shall be permitted in accordance with the sequencing of pumps requirements for electric drive controllers.
3. Transfer of power to the fire pump controller between the normal supply and one alternate supply shall take place within the pump room.
4. Protective devices installed in the on-site power source circuits at the generator shall allow instantaneous pickup of the full pump room load and shall comply with NFPA 70.

D. Where fire pump wiring to or from a fire pump controller is routed through a junction box, the following requirements shall be met:
1. The junction box shall be securely mounted.
2. Mounting and installation of a junction box shall not violate the enclosure type rating of the fire pump controller(s).

3. Mounting and installation of a junction box shall not violate the integrity of the fire pump controller(s) and shall not affect the short circuit rating of the controller(s).
4. As a minimum, Type 2, drip proof enclosure (junction box) shall be used. The enclosure shall be listed to match the fire pump controller enclosure type rating.
5. Terminals, junction blocks, and splice, where used, shall be listed.
6. A fire pump controller of fire pump power transfer switch, where provided, shall not be used as a junction box to supply other equipment, including a pressure maintenance (jockey) pump(s).

E. Listed electrical circuit protective system to controller wiring:
1. Where single conductors (individual conductors) are used, they shall be terminated in a separate junction box.
   a. The junction box shall be installed ahead of the fire pump controller, a minimum of twelve (12) inches beyond the fire-rated wall of floor bounding the fire zone.
   b. Single conductors (individual conductors) shall not enter the fire pump enclosure separately.
2. Where required by the manufacturer of a listed electrical circuit protective system, by NFPA 70, of by the listing, the raceway between a junction box and the fire pump controller shall be sealed at the junction box end as required and in accordance with the instructions of the manufacturer.
3. Standard wiring between the junction box and the controller shall be considered acceptable.

F. Raceway terminations:
1. Listed conduit hubs shall be used to terminate raceway (conduit) to the fire pump controller.
2. The type rating of the conduit hub(s) shall be at least equal to that of the fire pump controller.
3. The installation instructions of the manufacturer of the fire pump controller shall be followed.
4. Alterations to the fire pump controller, other than conduit entry as allowed by NFPA 70, shall be approved by the authority having jurisdiction.
5. Where the raceway (conduit) between the controller and motor is not capable of conducting ground fault current sufficient to trip the circuit breaker when a ground fault occurs, a separate equipment grounding conductor shall be installed between the controller and motor.

3.5 ELECTRIC DRIVE CONTROLLER INSTALLATION

A. Location:
1. Controllers shall be located as close as is practical to the motors they control and shall be within sight of the motors.
2. Controllers shall be located or protected so that they will not be damaged by water escaping from pumps or pump connections.
3. Current-carrying parts of controllers shall be not less than twelve (12) inches above the floor level.
4. Working clearances around controllers shall comply with NFPA 70.

B. Power transfer for alternate power supply:
1. General:
   a. Manual transfer switches shall not be used to transfer power between the normal supply and the alternate supply to the fire pump controller.

b. No remote device(s) shall be installed that will prevent automatic operation of the transfer switch.

2. Fire pump controller and transfer switch arrangements:
   a. Individually listed fire pump controller and power transfer switch:
      1) A fire pump controller power transfer switch and a fire pump controller shall be provided.
      2) The transfer switch overcurrent protection for both the normal and alternate sources shall comply with NFPA 20.
      3) The transfer switch overcurrent protection shall be selected or set to indefinitely carry the locked rotor current of the fire pump motor where the alternate source is supplied by a second utility.
      4) An isolating switch ahead of the alternate source input terminals of the transfer switch shall meet the following requirements:
         a) The isolating switch shall be lockable in the on position.
         b) A placard shall be externally installed on the isolating switch stating, "Fire Pump Isolating Switch," with letters at least one (1) inch in height.
         c) A placard shall be placed adjacent to the fire pump controller stating the location of the isolating switch and the location of the key (if the isolating switch is locked).
         d) The isolating switch shall be supervised to indicate when it is not closed, by one of the following methods:
            (1) Central station, proprietary, or remote station signal service.
            (2) Local signaling service that will cause the sounding of an audible signal at a constantly attended point.
            (3) Locking the isolating switch closed.
            (4) Sealing of isolating switches and approved weekly recorded inspections where isolating switches are located within fenced enclosures or in buildings under the control of the owner.
         e) This supervision shall operate an audible and visible signal on the transfer switch and permit monitoring at a remote point where required.
   b. Each fire pump shall have its own dedicated transfer switch(es) where a transfer switch(es) is required.

END OF SECTION

SECTION 22 01 00

PLUMBING GENERAL REQUIREMENTS

PART 1 GENERAL

1.1 STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. The general conditions shall be carefully examined before proposals for any work are submitted. Division twenty-two shall not be interpreted as waiving or overruling any requirements expressed in the general conditions unless division twenty-two specifications contain statements more definitive or more restrictive.

C. Nothing herein contained shall be so construed as to relieve the contractor from performing their work according to the true intent and meaning of the contract drawings and specifications. The contractor will be held responsible to provide all materials and equipment and shall provide all labor necessary for the complete, prompt, and satisfactory execution of the work. The contractor is also responsible for the proper coordination of their work with all other trades.

D. The contractor shall bear all expenses incidental to the satisfactory completion of the work contained in the contract drawings and specifications.

1.2 DEFINITIONS

A. Where words and phrases used throughout the contract documents are not specifically defined below or in the reference standards, they shall be interpreted by the meanings given to them in the latest edition of the Merriam-Webster dictionary.

B. Words and phrases used throughout the contract documents shall be interpreted as indicated below:

1. 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.
2. Others: A person or organization other than the contractor, owner, or professional.
3. Owner: The person or organization that awards the construction contract, or their designated representative.
4. Professional: The engineer of record.
5. Provide: To furnish and install materials, equipment, or systems.
6. Submittals: Industry standards, manufacturer’s data, manufacturer’s warranties, operation and maintenance instructions, shop drawings, and test reports.
7. Work: All labor, materials, equipment, and services necessary and reasonably incidental to the proper completion and proper operation of the plumbing systems.

1.3 REFERENCES

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. The contractor shall obtain all licenses, permits, etc. and shall pay all associated connection fees, tapping fees, inspection fees, etc. These costs shall be included in the contract price.

B. The publications listed below form a part of this specification. All publications shall be the latest edition as adopted by the authority having jurisdiction at the date of bid advertisement. The minimum standard of work under this contract shall be in accordance with the following model building codes or standards:

1. ASTM International:
   a. ASTM C33 – Standard Specification for Concrete Aggregates.
   b. ASTM C94 – Standard Specification for Ready-Mixed Concrete.
   c. ASTM C150 – Standard Specification for Portland Cement.
   d. ASTM C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   e. ASTM C989 – Standard Specification for Slag Cement for Use in Concrete and Mortars.
   f. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   g. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
2. International Building Code (IBC) with North Carolina Amendments:
   a. North Carolina Building Code.
   b. North Carolina Energy Conservation Code.
   c. North Carolina Fire Prevention Code.
   d. North Carolina Fuel Gas Code.
   e. North Carolina Mechanical Code.
   f. North Carolina Plumbing Code.
3. National Fire Protection Association:
   a. NFPA 70 – National Electric Code.

1.4 SCOPE

A. Domestic water systems: The domestic water systems shall be extended to all equipment and accessories, including those provided by others as determined in the construction contract. For systems with piping outside of the building, the systems shall be extended from a point five (5) feet beyond the exterior face of the building. Final installation at the point of utility connection shall be made by the contractor.

B. Sanitary waste systems: The sanitary waste systems shall be extended to all equipment and accessories including those provided by others as determined in the construction contract. For systems with piping outside of the building, the systems shall be extended from a point five (5) feet beyond the exterior face of the building. Final installation at the point of utility connection shall be made by the contractor.

C. Fuel gas systems: The fuel gas systems shall be extended to all equipment and accessories, including those provided by others as determined in the construction contract. For systems with piping outside of the building, the systems shall be extended from a point five (5) feet beyond the exterior face of the building. Final installation at the point of utility connection shall be made by the contractor.

1.5 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:

1. General contractor:
   a. Downspouts and gutters.
   b. New catch basins and foundation drains.
   c. The contractor shall furnish access panels to the general contractor for installation.
   d. The contractor shall make all final connections to owner supplied equipment. The contractor shall be responsible for coordination of plumbing services with the equipment.
   e. The contractor shall furnish and/or install casework mounted fixtures and equipment where not furnished and/or installed by others. Where fixtures and equipment are furnished by others, the contractor shall install these items in accordance with the contract drawings and specifications. Rough-in plumbing work shall be in accordance with rough-in drawings provided by others. The contractor shall make the final connections to all fixtures and equipment. The contractor shall be responsible for coordination of plumbing services with the fixtures and equipment.
   f. Concrete housekeeping and structural pads for equipment.
   g. Cast-in-place concrete sumps, interceptors, and receivers.
   h. Cutting and patching: The general contractor shall perform cutting and patching of floors, exterior walls, and roofs when necessary for the installation of the work.
   i. The general contractor shall provide final painting of walls, floors, and ceilings where the surfaces are new, refinished, and remodeled under the general contract. The general contractor shall perform all required painting of piping provided by the contractor.
2. Electrical contractor:
   a. Verification of the proper rotation of three-phase equipment, and any modifications required to correct improper rotation.
   b. Installation of all combination starters/disconnects and overload protectors.
   c. Installation of all line side junction boxes and/or receptacles servicing low voltage control transformers.
3. HVAC contractor:
   a. HVAC makeup water connections downstream of contractor provided backflow prevention devices.
   b. Condensate drain piping associated with HVAC equipment.
   c. The contractor shall install pipeline mounted metering and control devices furnished by the HVAC contractor for connection to the building

automation system, or similar monitoring system(s), located in systems provided by the contractor. All control wiring shall be provided by the HVAC contractor.

1.6 QUALITY ASSURANCE

A. The contractor shall become thoroughly familiarized with all specifications and drawings for the project such that they clearly understand their responsibility in relationship to the work to be performed. The contractor shall plan and perform their work so as to permit the use of the building at the earliest possible date.

B. The contractor shall coordinate their work with that of the other trades. Where interference with other trades occurs, the contractor shall present their solution to the professional. The professional shall make the final decision regarding changes to be made in the work.

C. The contractor is responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the contract documents.

D. The contractor shall expressly and completely follow the manufacturer’s instructions required for validation of the manufacturer’s warranty, including but not limited to service, maintenance, and adjustment of the equipment.

E. The contractor shall guarantee all work, materials, and equipment furnished against defects, leaks, performance, and nonoperation for a period of one (1) year after the date of the owner’s final acceptance, or as indicated in the general conditions. Defects shall be interpreted as defective materials or equipment or unsatisfactory installation and are not intended to apply to ordinary wear and tear. The contractor shall pay for any repairs or replacements caused by these defects within the period covered by the guarantee, including all incidental work required to fix the deficiency.

1.7 MATERIALS

A. Each length of pipe and each pipe fitting, trap, fixture, material, and device utilized in all plumbing systems shall bear the identification of the manufacturer and the applicable standard to which it was manufactured.

B. All plumbing products and materials shall comply with the referenced standards, specifications, and performance criteria of the contract documents. Where required, plumbing products and materials shall either be tested by an approved third-party testing agency or certified by an approved third-party certification agency.

C. All piping materials exposed within plenums shall comply with the provisions of the North Carolina Mechanical Code.

D. Equipment efficiencies shall be in accordance with the North Carolina Energy Conservation Code.

E. Solders with lead content exceeding two-tenths (0.2) percent are prohibited. Brass and bronze materials with lead content two (2) percent or greater are prohibited.

F. Provide products requiring electrical connections listed and classified by Underwriters Laboratories, Inc. (UL), as suitable for the purpose specified and indicated.

1.8 FIELD MEASUREMENTS

A. The contractor is responsible to verify the location of any and all existing underground utilities in the vicinity of their 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. The contractor is responsible for the correctness of this information.

C. Any difference identified by the contractor shall be submitted to the professional for consideration before proceeding with the work.

D. No extra compensation will be considered based on differences between actual dimensions or measurements and those indicated on the drawings.

1.9 PROTECTION OF UTILITIES

A. All existing service utilities shall remain active during construction. Any service underground, aboveground, interior, or exterior that is damaged, broken, or otherwise rendered inoperative during the course of construction due to activities on the part of the contractor shall be properly repaired by the contractor at their own expense. The method used in repairing, replacing, or maintaining the services shall be submitted to the professional for review and approval.

B. Ashes, cinders or rags; flammable, poisonous or explosive liquids or gases; oil, grease or any other insoluble material capable of obstructing, damaging or overloading the building drainage or sewer system, or capable of interfering with the normal operation of the sewage treatment process or private disposal system, shall not be deposited into such systems.

1.10 INTERRUPTION OF UTILITIES

A. The contractor shall schedule their work to avoid interruption of any utility services.

B. Existing utilities serving occupied facilities shall not be interrupted, except when such interruptions have been authorized by the owner and the professional. Interruptions may occur only after acceptable temporary utility services have been provided. The contractor shall provide a minimum of ten (10) working days' notice to the owner and receive written notice to proceed before interrupting any utility.

1.11 STRUCTURAL SAFETY

A. The work shall be installed with due regard to preservation of the strength of structural members and prevention of damage to wall and other surfaces through fixture usage.

B. In the process of installing or repairing any part of a plumbing system, the finished floors, walls, ceilings, tile work, or any other part of the building or premises that must be changed or replaced shall be left in a safe structural condition in accordance with the North Carolina Building Code.

C. The cutting, notching, and boring of holes in structural steel framing members shall be as prescribed by the structural engineer.

D. Flanges and lips of load-bearing cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing, or minimum hole edge distance as prescribed by the structural engineer. Cutting, notching, and boring holes of steel floor or roof decking shall be as prescribed by the structural engineer.

E. Flanges and lips of nonstructural cold-formed steel wall studs shall not be cut or notched. Holes in webs of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed one-and-one-half (1-1/2) inches in width or four (4) inches in length, and the holes shall not be spaced less than twenty-four (24) inches center to center from another hole or less than ten (10) inches from the bearing end.

F. Truss members and components shall not be cut, drilled, notched, spliced, or otherwise altered in any way without written concurrence and approval of the structural engineer. Alterations resulting in the addition of loads to any member shall not be permitted without verification that the truss is capable of supporting such additional loading.

G. Trenches installed parallel to footings shall not extend below the forty-five (45) degree bearing plane of the footing or wall.

1.12 RODENTPROOFING

A. All strainer plates on drain inlets shall be designed and installed so that all openings are not greater than one-half (1/2) inch in least dimension.

B. Where openings have been made in walls, floors, or ceilings for the passage of pipes, such openings shall be closed and protected by the installation of approved metal collars or other approved materials that are securely fastened to the adjoining structure.

C. Annular spaces around pipes, electric cables, conduits, or other openings in the foundation or exterior walls shall be protected against the passage of rodents by closing such openings with cement mortar, concrete masonry, silicone caulking, or noncorrosive metal.

1.13 PROTECTION OF WORK

A. Plumbing systems shall not be located in an elevator shaft or in an elevator equipment room. Floor drains, sumps, and sump pumps shall be permitted at the base of an elevator shaft when intended for the specific purpose of dewatering and are installed in accordance with the North Carolina Department of Labor requirements.

B. Pipes passing through or under walls shall be protected from breakage.

C. Piping shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe. Where necessary, provisions shall be made to protect piping from damage resulting from expansion, contraction, and structural settlement.

D. Any pipe that passes within twelve (12) inches under a footing or through a foundation wall shall be provided with a relieving arch, or a pipe sleeve pipe shall be built into the foundation wall. The sleeve shall be two (2) pipe sizes greater than the pipe passing through the wall. Piping shall not be run under pier footings.

E. The top of water pipes, installed below grade outside the building, shall be below the frost line or a minimum of twelve (12) inches below finished grade, whichever is greater. Water pipes installed in a wall exposed to the exterior shall be installed on the heated side of the wall insulation. Water piping installed in an unconditioned space shall have insulation with a minimum R-factor of six-and-one-half (6.5) determined at seventy-five (75) degrees Fahrenheit in accordance with ASTM C177.

F. No traps of soil or waste pipe shall be installed or permitted outside of a building, or concealed in outside walls, or in any place where they may be subjected to freezing temperatures, unless adequate provision is made to protect them from freezing. Waste and soil piping leaving the building shall have a minimum cover of three (3) inches.

G. In concealed locations where piping, other than cast iron or galvanized steel, is installed through holes or notches in studs, joists, rafters, or similar members less than one-and-one-half (1-1/2) inches from the nearest edge of the member, the pipe shall be protected by steel shield plates. Such shield plates shall have a thickness of not less than sixteen (16) gauge. Such plates shall cover the area of the pipe where the member is notched or bored and shall extend a minimum of two (2) inches above sole plates and below top plates.

H. Components of plumbing systems installed along alleyways, driveways, parking garages, or other locations exposed to damage shall be recessed into the wall or otherwise protected in an approved manner.

I. At their own expense, the contractor shall protect their work, materials, or equipment that is subject to damage during the project duration. All openings into any piping, ducts, or equipment shall 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 is responsible for all damage until their work is fully and finally accepted.

J. The use of plumbing fixtures prior to final acceptance by the owner is prohibited.

1.14 CHASES AND OPENINGS

A. All chases and openings required for the installation of the work shall be coordinated with the work of other trades. The contractor shall provide the other trades with sufficient time for coordination of all chases and openings. The contractor shall be responsible for cutting and patching all openings in walls and ceilings necessary for their work.

B. The contractor shall provide all sleeves, hangers, and anchors required for installation of the work in chases and openings.

C. Pipes passing through concrete or cinder walls and floors or other corrosive material shall be protected against external corrosion by a protective sheathing or wrapping or other means that will withstand any reaction from the lime and acid of concrete, cinder, or other corrosive material. Sheathing or wrapping shall allow for movement including expansion and contraction of piping. Minimum wall thickness of material shall be twenty-five-one-thousandths (0.025) inch.

D. Annular spaces between sleeves and pipes shall be filled in an approved manner. Annular spaces between sleeves and pipes in fire-resistance-rated assemblies shall be firestopped in accordance with specification section 22 05 32.

E. Joints at the roof and around vent pipes, shall be made water-tight by the use of lead, copper, galvanized steel, aluminum, plastic, or other approved flashings or flashing material. Exterior wall openings shall be made water tight.

1.15 MISCELLANEOUS STEEL AND ACCESSORIES

A. The contractor shall provide all necessary steel angles, channels, pipes, rods, nuts, bolts, etc. as shown on plans, as specified, or as may be required for the 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.

1.16 CROSS CONNECTION CONTROL

A. The contractor shall coordinate water service requirements in accordance with the local water utility regulations, including required permits, backflow preventers, meters, piping, valves, bypasses, supports, and other accessories.

B. Where these services are provided by others, the contractor shall verify that they are complete and have been inspected prior to making final connection(s).

1.17 CLEANUP

A. 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 is not permitted.

B. 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, the site and public properties shall be cleaned and waste materials, debris, and rubbish disposed of in an appropriate manner.

C. At the completion of the project, the contractor shall 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 the specified finish or to match adjacent surfaces.

1.18 PROJECT CLOSEOUT DOCUMENTATION

A. Changes from the contract documents 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 documents. 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 utility lines.
2. Changes in pipe size and routing location.
3. Valve locations.
4. Equipment locations.
5. Actual capacities and values of equipment provided as indicated in equipment schedules or specifications.

C. The marked-up record set of construction documents shall be delivered to the professional before final acceptance of the work.

D. The contractor shall deliver operation and maintenance manuals per section 22 01 05 to the professional before instruction of the owner and after final acceptance of the work.

1.19 INSTRUCTION OF THE OWNER

A. After acceptance of the project, the contractor shall provide 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 ten (10) business days' advance notice before the instruction session(s).

PART 2 PRODUCTS

2.1 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 twelve (12) by sixteen (16) inches.

C. Access door locations shall be as determined by field conditions for optimum access to equipment and shall be reviewed by the owner before final installation. Access door locations 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 six (6) inches above floor.

2. Tops and/or sides of access panels shall be a minimum of six (6) inches from the ceiling or opening of from the edge of a wall.

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 fire-rated construction assemblies. Access doors shall be “B-Label” and shall have a UL rating for both door and frame matching that of the wall in which it is installed. Maximum size shall be twenty (20) inches by twenty (20) inches or four hundred (400) square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel.

G. Access doors without UL label shall be provided in all non-fire-rated construction assemblies. Frames shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel.

H. 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.

I. Door shall open one-hundred-seventy-five (175) degrees minimum.

J. All access doors shall be keyed alike.

PART 3 EXECUTION

3.1 GENERAL

A. The contract documents are diagrammatic and are indicative of the work to be performed. It is not intended that they show every pipe, fitting, offset, change in direction, or appurtenance required for a complete installation.

B. All materials used shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer’s installation instructions shall be followed.

3.2 EXCAVATION, BACKFILLING, COMPACTION, AND RESURFACING

A. 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. The contractor shall provide all bracing, sheathing, and shoring necessary to perform and protect their excavations. The contractor shall provide safety rails, lights, signs, etc. as necessary or required for safety, or as required to conform to governing codes and laws.

4. The contractor shall provide, maintain, and operate pumping equipment of sufficient capacity to ensure that all their excavations and trenches are kept free of water at all times.

5. The contractor shall 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 from excavation operations.

6. Existing utility lines shown on the contract documents do not indicate the exact location of the lines. The location and depth of all utilities shall be marked and recorded prior to any excavation. Should uncharted or incorrectly charted piping or other utilities be uncovered during excavation, the contractor shall contact the professional for directions before proceeding further with work in this area.

7. All surfaces of streets, walkways, seeded areas, or finished grade areas disturbed by the excavation shall be restored to their original condition and/or as indicated in the contract documents.

8. The presence of explosives on the project site or the use of explosives in the execution of the work under this contract is prohibited.

9. Buried piping shall be supported throughout its entire length.

B. Trenching and bedding:

1. All plumbing excavation is unclassified.

2. If trench excavation operations are performed when the atmospheric temperature is less than thirty-five (35) degrees Fahrenheit, the contractor shall provide cold weather protection as required to protect excavated trench bottoms from freezing. Piping shall not be placed in a trench containing water or on a subgrade containing frost.

3. Take up and relay pipe that is not laid true to required alignment or grade. Pipe that has had its joints disturbed after installation shall be taken up and relayed. Deviation from the required lines and grades will not be permitted unless approved by the professional.

4. Trenches shall be dug to uniform width not less than twelve (12) inches and not more than sixteen (16) inches wider than the bell diameter of the piping. Trench sides shall be vertical. Carry depth of trenches for piping as required to establish required slopes and invert elevations. Beyond building perimeter, keep bottom of trenches sufficiently below finished grade to protect against frost. The bottom of trenches shall be accurately graded to provide uniform and smooth flow throughout.

5. Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Bell holes, hub holes, and coupling holes shall be provided at points where piping is joined. Such pipe shall not be supported on blocks to grade.

6. Where trenches are excavated below the installation level of the pipe such that the bottom of the trench does not form the bed for the pipe, the trench shall be backfilled to the installation level of the bottom of the pipe with sand or fine gravel placed in layers of six (6) inches maximum depth and such backfill shall be compacted after each placement.

7. Where rock is encountered in trenching, the rock shall be removed to a minimum of three (3) inches below the installation level of the bottom of the pipe, and the

trench shall be backfilled to the installation level of the bottom of the pipe with sand tamped in place so as to provide uniform load-bearing support for the pipe between joints. The pipe, including joints, shall not rest on rock at any point.

8. If soft materials of poor load-bearing quality are found at the bottom of the trench, stabilization shall be achieved by over-excavating a minimum of two (2) pipe diameters and backfilling to the installation level of the bottom of the pipe with fine gravel, crushed stone, or a concrete foundation. The concrete foundation shall be bedded with sand tamped into place so as to provide uniform load-bearing support for the pipe between joints.

9. All underground piping shall be laid on first class granular bedding. The bedding shall be a minimum depth of six (6) inches or one-fourth (1/4) the pipe diameter, whichever is greater. The bedding shall provide uniform longitudinal support to the pipe and shall be laid to provide the grade and line as shown on the drawings or as directed by the professional. Hand-tamp the embedment materials under the haunches and around the pipe to the spring-line of the pipe to a compaction density of ninety-five (95) percent. Final embedment for ferrous pipe materials shall extend from the spring-line of the pipe to a depth of six (6) inches minimum above the top of the pipe. Final embedment for nonmetallic pipe shall extend from the spring-line of the pipe to a depth of eighteen (18) inches minimum above the top of the pipe.

C. Backfilling:

1. Backfilling shall not be undertaken until all tests and inspections have been made.

2. When the type of backfill, material is not indicated on the plans or is not specified, the excavated material may be used, provided that such material consists of loam, clay, sand, gravel, or other material that is suited for backfilling. From one (1) foot above the top of the pipe to subgrade, material containing stones greater than three (3) inches in their greatest dimension may not be used.

3. Backfill shall be free from discarded construction material and debris. Loose earth free from rocks, broken concrete, and frozen chunks shall be placed in the trench in six (6) inch layers and tamped in place until the crown of the pipe is covered by twelve (12) inches of tamped earth. The backfill under and beside the pipe shall be compacted for pipe support. Backfill shall be brought up evenly on both sides of the pipe so that the pipe remains aligned.

4. Backfill trenches to a depth of twelve (12) inches above the top of the outside barrel of the pipe. Continue thereafter with the backfill in twelve (12) inch lifts.

D. Compaction:

1. Compaction shall be accomplished by approved equipment suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

2. Compacting of this backfill by puddling or jetting will not be permitted. Use mechanical tampers to compact backfill materials in trench refill operations to produce a density of backfill at the bottom of each layer of not less than ninety-five (95) percent of the maximum density obtained at optimum moisture content, in accordance with ASTM D1557, method D and ASTM D1556, sand cone method.

3. The use of specialty equipment for compaction of backfill is prohibited.

E. Resurfacing:

1. All trenches backfill shall be brought to subgrade, ready for base material or topsoil. After the initial aggregate backfill, layer has been placed, refill the remainder of the trench using backfill materials as follows:

   a. Lawns: Successive six (6) inch layers of clean earth backfill material shall be deposited after initial aggregate backfill. This backfill shall consist of excavated material free from large clods of earth and stone. If stones greater than three (3) inches are encountered, remove stones from the site and haul in clean earth backfill. The entire trench shall be uniformly tamped after each successive layer is deposited. Replace topsoil to its original depth and crown to such height as required.

   b. Walks and parking areas: Clean earth backfill compacted in six (6) inch layers to a depth of eight (8) inches below the adjacent existing surfaces. Refill the remaining eight (8) inches with compacted stone and replace walk or paving as required.

   c. Paved areas: When working within the right-of-way limits of all state highways, backfilling must be in accordance with the requirements of the State Department of Transportation. Trenches located within the areas described above shall be backfilled with aggregate material from the top of the pipe bedding to the bottom elevation of the pavement structure and must be spread and compacted in layers not to exceed four (4) inches when using a mechanical damper. The contractor is to understand that payment for special backfilling material shall not be made unless specifically provided in the form of a proposal.

3.3 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 five (5) working days prior to testing to coordinate the testing and inspection procedures.

3. The contractor shall provide all equipment, material, labor, etc. required for testing the plumbing systems.

4. All new, altered, extended, or replaced plumbing systems 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 their own expense as directed by the professional.

5. If the professional determines that the plumbing systems do not pass the prescribed tests, the contractor shall be required to make the necessary repairs at their own expense. The contractor shall inspect and retest the systems. Repairing, inspection, and testing shall be continued until all systems pass as determined by the professional.

B. Test gauges:

1. Tests requiring a pressure of ten (10) psi or less shall utilize a testing gauge having increments of one-tenth (0.1) psi or less.

2. Tests requiring a pressure of greater than ten (10) psi but less than or equal to one hundred (100) psi shall utilize a testing gauge having increments of one (1) psi or less.

3. Tests requiring a pressure of greater than one hundred (100) psi shall utilize a testing gauge having increments of two (2) psi or less.

END OF SECTION

SECTION 22 01 05

PLUMBING SUBMITTAL REQUIREMENTS

PART 1 GENERAL

1.1 STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. Submittals shall be made in separate packages containing all the required documentation indicated in each specification section. Only one (1) submittal package shall be made for each specification section. Partial submissions will not be addressed.

C. Failure of the contractor to provide a complete submittal package may result in delay in processing time. All such delays to the project resulting from the contractor's failure to provide submittals in a timely fashion will be the responsibility of the contractor.

1.2 DEFINITIONS

A. Industry standard: Printed copies of the current standards recognized in the industry. Current means the latest issue as of the date of these specifications; within the text of these specifications the date suffix frequently shown with identification numbers has been omitted.

B. Manufacturer's data: Product manufacturer's standard printed product information, including promotional brochures, product specifications, installation instructions and diagrams, statements of compliance with standard performance charts or curves, and similar information concerning the standard portions of manufacturer's products.

C. Manufacturer's warranty: Manufacturer's standard printed commitment in reference to a specific product and normal application, stating that certain acts of restitution will be performed for the purchaser or owner by the manufacturer, when and if the product fails within certain operational conditions and time limits.

D. Operation and maintenance instructions: The written instructions by the manufacturer, fabricator, or installer of equipment or systems, detailing the procedures to be followed by the owner in operation, control, and shutdown of each operating item of the equipment.

E. Shop drawings: Project shop drawings and other data prepared specifically for fulfillment of the project requirements. Shop drawings include fabrication, layout, setting, installation, coordination, and similar drawings and diagrams, and include performance data associate therewith, including weights, capacities, speeds, outputs, consumption, efficiencies, voltages, amperages, cycles, phases, noise levels, operating ranges, and similar information.

F. Test reports: Specific reports prepared by independent testing laboratories and others, showing the results of specified testing on either the material or equipment provided or on identical material or equipment.

1.3 SUBSTITUTIONS

A. Submittals are not opportunities for gaining acceptance of substitutions. Where three or more manufacturers are specified by name or by catalog reference, the contractor shall select for use any of those so specified.

B. Should the contractor desire to substitute another manufacturer's equipment for one specified by name, the contractor shall apply in writing at least ten (10) business days prior to bid date for such permission. The contractor shall provide supporting data for the professional's consideration. No substitution shall be made for any material, article, or process under the contract unless approved by the professional.

C. Any time that is required by the professional for a request to review submittals for substitute equipment after the award of bids will be billed to the contractor at the professional's current hourly billing rate. The professional's review time will be billed to the contractor whether the proposed substitution is accepted or rejected.

1.4 SUBMITTAL FORM AND PROCEDURES

A. Submittals shall be assembled as single file electronic submittals. Transmittals shall be included within the file as the first page.

B. Submittals shall be made in separate packages containing all the required documentation indicated in each specification section. A separate submittal package shall be made for each specification section.

C. Submittals shall be complete and clearly identified and cross-referenced to the appropriate specification section defining the submitted item.

D. After checking and verifying all field measurements, the contractor shall submit copies of all submittals to the professional for review. The data shown on the submittals shall be complete with respect to dimensions, design criteria, materials of construction, and the like to enable the professional to review the information as required.

E. The contractor shall stamp the submittals and verify by signature that the submittals have been checked for compliance with the contract documents and appropriate means have been taken to ensure that the material or equipment will fit into the space available.

F. At the time of each submission, the contractor shall in writing call the professional's attention to any deviations that the submittal may have from the requirements of the contract documents.

G. The submittals shall be clearly marked indicating which specific options are being considered and with all related information.

H. The professional's review of submittals is for general conformance with design concept only. Corrections or comments made on the submittals during review do not relieve the contractor from compliance with requirements of the contract documents.

I. The contractor is responsible for all quantities, dimensions, and coordination of the work of all trades. The contractor is responsible for selecting fabrication processes and techniques of construction and for performing all work in a safe and satisfactory manner.

J. No work requiring a submittal shall be commenced until the submittal has been reviewed by the professional.

K. A copy of each approved submittal shall be kept in good order by the contractor and shall be made available at the site.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Submit after final inspection for review by the professional.

B. The contents of the submittal shall be prepared as follows:

1. Table of contents.
2. A directory listing names, addresses, and telephone number of professional, contractor, subcontractors, and equipment suppliers.
3. Project documents and certificates:
    a. Certificates of compliance.

b. Photocopies of warranties and bonds.

c. Material safety data sheets (MSDS).

4. Operation and maintenance instructions subdivided by specification section. For each item, identify the following:

a. Significant design criteria.

b. List of equipment.

c. Parts list for each component.

d. Maintenance instructions for equipment and systems.

e. Maintenance instructions for finishes including recommended cleaning methods and materials and operating instructions.

f. Special precautions identifying detrimental agents.

g. Special requirements of other sections of this specification noted to be included in the operation and maintenance manual.

C. Submit five (5) copies for review by the owner ten (10) business days prior to owner training.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Pipe hangers and supports.
2. Inserts.
3. Flashing.
4. Sleeves.
5. Mechanical sleeve seals.

1.2 REFERENCES

A. Manufacturers Standardization Society:

1. MSS SP 58 – Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data for the following:

1. Pipe hangers and supports.
2. Inserts.
3. Flashing.
4. Sleeves.
5. Mechanical sleeve seals.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data, manufacturer’s warranties, and operation and maintenance instructions for the following:

1. Pipe hangers and supports.
2. Inserts.
3. Flashing.
4. Sleeves.
5. Mechanical sleeve seals.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Conform to applicable portions of MSS SP 58.

B. Provide copper or copper-plated supports for copper piping.

C. Design hangers for pipe movement without disengagement of supported pipe.

D. Obtain permission from the professional before using powder-actuated anchors.

E. Suspended supports:

1. Two (2) inches or less: Carbon steel, adjustable swivel, split ring.

2. Two (2) to four (4) inches: Carbon steel, adjustable, clevis.

3. Trapeze hangers: Steel channels with welded supports or spacers and hanger rods.

F. Wall supports:

1. Three (3) inches or less: Cast iron hooks.

2. Four (4) inches to six (6) inches: Welded steel bracket and wrought steel clamps.

G. Floor supports:

1. Four (4) inches or less: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

H. Vertical supports: Steel riser clamp.

I. Hanger rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

J. Hangers, anchors, and supports shall support the piping and the contents of the piping. Hangers and strapping material shall be of approved material that will not promote galvanic action.

2.2 INSERTS

A. 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.

2.3 FLASHING

A. Metal flashing: twenty-six (26) gauge galvanized steel.

B. Metal counter-flashing: twenty-two (22) gauge galvanized steel.

C. Lead flashing:

1. Waterproofing: five (5) lb/ft^2 sheet lead.

2. Soundproofing: one (1) lb/ft^2 sheet lead.

D. Flexible flashing: forty-seven (47) mil sheet butyl; compatible with roofing.

E. Caps: twenty-two (22) gauge steel; sixteen (16) gauge at fire-rated assemblies.

2.4 SLEEVES

A. Non-fire-rated floors: Eighteen (18) gauge galvanized steel.

B. Non-fire-rated beams, walls, footings, and potentially wet floors: Steel pipe or eighteen (18) gauge galvanized steel.

C. Sealant: Acrylic.

2.5 MECHANICAL SLEEVE SEALS

A. 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.

PART 3 EXECUTION

3.1 PIPE HANGER AND SUPPORT INSTALLATION

A. Conform to applicable portions of MSS SP 58.

B. Hangers and anchors shall be attached to the building construction in an approved manner.

C. Bases of stacks shall be supported by the building structure, virgin or compacted earth, or other material suitable to support the weight of the piping.

D. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

E. Use hangers with one-and-one-half (1-1/2) inch minimum vertical adjustment.

F. Provide clearance in hangers and from structure and other equipment for installation of insulation. Refer to specification section 22 07 00.

G. Install hangers with minimum one-half (1/2) inch space between finished covering and adjacent work.

H. Place hangers within twelve (12) inches of each horizontal elbow.

I. Where piping is installed in parallel and at same elevation, provide trapeze hangers.

J. Support vertical piping independently of connected horizontal piping.

K. Support vertical piping at ever floor. Support vertical cast iron pipe at each floor at hub.

L. Piping shall be supported in accordance with the following:

PIPING MATERIAL	MAXIMUM HORIZONTAL SPACING (ft)	MAXIMUM VERTICAL SPACING (ft)
Cast Iron Pipe	5[1]	15
Copper or Copper-Alloy Pipe	12	10
Copper or Copper-Alloy Tubing (less than 1-1/2”)	6	10
Copper or Copper-Alloy Tubing (more than 1-1/4”)	10	10

1. The maximum horizontal spacing of cast iron pipe hangers shall be increased to ten (10) feet where ten (10) foot lengths of pipe are installed.

3.2 INSERT INSTALLATION

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 four (4) inches and larger.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 FLASHING INSTALLATION

A. Provide flexible flashing and metal counterflashing where piping penetrates weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting three (3) inches minimum above finished roof surface with lead worked one (1) inch minimum into hub, eight (8) inches minimum clear on sides with twenty-four (24) by twenty-four (24) inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counter-flash, and seal.

C. Flash floor drains in floors with topping over finished areas with lead, ten (10) inches clear on sides with minimum thirty-six (36) by thirty-six (36) inch sheet size. Fasten flashing to drain clamp device.

D. Seal floor, shower, mop sink, etc. drains watertight to adjacent materials.

3.4 SLEEVE INSTALLATION

A. Verify openings are ready to receive sleeves.

B. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of sealant material.

C. Install backing or damming materials to arrest liquid material leakage.

D. Exterior watertight entries: Seal with mechanical sleeve seals.

E. Set sleeves in position in forms. Provide reinforcing around sleeves.

F. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

G. Extend sleeves through floors two (2) inches above finished floor level. Caulk sleeves.

H. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent work with stuffing insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

I. Install chrome-plated steel escutcheons at finished surfaces.

END OF SECTION

SECTION 22 05 32

FIRESTOPPING FOR PLUMBING SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Firestopping relating to plumbing work.
2. Firestopping accessories.

1.2 REFERENCES

A. ASTM International:

1. ASTM E84 – Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E814 – Test Method of Fire Tests of Through Penetration Firestops.

B. Underwriters Laboratories, Inc.:

1. UL 723 – Tests for Surface Burning Characteristics of Building Materials.
2. UL 1479 – Fire Tests of Through-Penetration Firestops.

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 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:

1. Firestopping relating to plumbing work.
2. Firestopping accessories.

C. Submit a 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. Submit manufacturer's preparation and installation instructions for each listed design number.

1.5 QUALITY ASSURANCE

A. Through-penetration firestopping of fire-rated assemblies: UL 1479, ASTM E814; with one-tenth (0.1) inch water gauge minimum positive pressure differential to achieve fire F-ratings and temperature T-ratings as indicated on life safety drawings, but not less than 1-hour.

B. Surface burning characteristics: Flame spread index of twenty-five (25) and smoke developed index of fifty (50) when tested in accordance with UL 723 or ASTM E84.

C. Perform work in accordance with the latest edition of the North Carolina Fire Prevention Code and any local codes, ordinances, or construction standards.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Do not apply firestopping materials when temperature of substrate material and ambient air is below sixty (60) degrees Fahrenheit.

B. Maintain this minimum temperature before, during, and for minimum three (3) days after installation of firestopping materials.

C. Provide ventilation in areas to receive solvent cured materials.

PART 2 PRODUCTS

2.1 FIRESTOPPING

A. 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/elastomeric firestopping: Single component silicone elastomeric compound and compatible silicone sealant.
2. Foam firestopping compounds: Single 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 fiber stuffing insulation with silicone elastomer for smoke stopping.
5. Intumescent firestopping: Intumescent putty compound which expands on exposure to surface heat gain.

B. Color: As selected from manufacturer’s full range of colors to match adjacent surfaces.

2.2 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.
2. Select products with rating not less than rating of wall or floor being penetrated.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Verify openings are ready to receive firestopping.

B. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

C. Remove incompatible materials affecting bond.

D. Install backing or damming materials to arrest liquid material leakage.

3.2 INSTALLATION

A. Install material at fire-rated construction perimeters and openings containing penetrating sleeves, piping and other items, requiring firestopping.

B. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.

C. Apply firestopping material in sufficient thickness to achieve required fire and smoke rating to uniform density and texture.

END OF SECTION

SECTION 22 05 48

VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Elastomeric hangers.
5. Snubbers.
6. Restraints - rigid type.
7. Restraints - cable type.
8. Restraint accessories.
9. Post-installed concrete anchors.
10. Concrete inserts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Include load rating for each wind-load-restraint fitting and assembly.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Consequential Damage: Provide additional restraints for suspended fire-suppression system components or anchorage of floor-, roof-, or wall-mounted fire-suppression system components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential fire-suppression system component will not cause the failure of any other essential architectural, mechanical, or electrical building component.

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

C. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
4. Surface Pattern: Smooth, ribbed, or waffle pattern.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil and water resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

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

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

2.5 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.

2.6 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.7 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.8 RESTRAINTS - CABLE TYPE

A. Seismic-Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

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

2.9 RESTRAINT ACCESSORIES

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

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

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

2.10 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-10, Ch. 13.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.11 CONCRETE INSERTS

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

B. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to high wind forces.

C. Strength of Support and Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind load within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL DEVICES

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

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

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

D. Equipment Restraints:

1. Install snubbers on fire-suppression equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

E. Piping Restraints:

1. Comply with all requirements in NFPA 13.
2. Design piping sway bracing according to NFPA 13.

    a. Maximum spacing of all sway bracing to be no greater than indicated in NFPA 13.
    b. Design loading of all sway bracing not to exceed values indicated in NFPA 13.

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

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Post-Installed Concrete 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. Mechanical-Type Anchor Bolts: 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-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL STRUCTURAL MOTION

A. Install flexible connections in piping where they cross structural construction joints and other points where differential movement may occur, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

3.5 ADJUSTING

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.6 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. 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 postconnection 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 no fewer than four of each type and size of installed anchors and fasteners.
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.

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

E. Units will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
   1. Pipe identification.
   2. Valve tags.
   3. Ceiling tacks.
   4. Nameplates.
   5. Labels.
   6. Lockout devices.

1.2 REFERENCES

A. ASME International:
   1. ASME A13.1 – Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data for the following:
   1. Pipe identification.
   2. Valve tags.
   3. Ceiling tacks.
   4. Nameplates.
   5. Labels.
   6. Lockout devices.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data, manufacturer’s warranties, and operation and maintenance instructions for the following:
   1. Pipe identification.
   2. Valve tags.
   3. Ceiling tacks.
   4. Nameplates.
   5. Labels.
   6. Lockout devices.

PART 2 PRODUCTS

2.1 PIPE IDENTIFICATION

A. Font and symbols conforming to ASME A13.1.

B. Colors shall match owner's standard.

C. With clean cut symbols and letters of following size:

1. Outside diameter two (2) inches or less: one-half (1/2) inch.
2. Outside diameter two-and-one-half (2-1/2) to six (6) inches: one (1) inch.

D. 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.

E. Plastic underground pipe tape:

1. Bright colored continuously printed plastic ribbon tape manufactured for direct burial service, minimum six (6) inches wide by four (4) mil.

2.2 VALVE TAGS

A. Font size conforming to ASME A13.1.

B. Colors shall match owner's standard.

C. Metal:

1. Brass with stamped letters, minimum one-and-one-half (1-1/2) inches diameter with finished edges.

D. Tag chart:

1. Typewritten list of applied tags and locations in anodized aluminum frame with polycarbonate cover.

2.3 CEILING TACKS

A. Font size conforming to ASME A13.1.

B. Colors shall match owner's standard.

C. Three-quarters (3/4) inch steel.

D. Adhesive attachment is prohibited.

2.4 NAMEPLATES

A. Font size conforming to ASME A13.1.

B. Colors shall match owner's standard.

C. Laminated three (3) layer plastic with engraved letters on contrasting background color.

2.5 LABELS

A. Font size conforming to ASME A13.1.

B. Colors shall match owner's standard.

C. Laminated Mylar adhesive backed with printed identification.

D. Two (2) by three-quarters (3/4) inches.

2.6 LOCKOUT DEVICES

A. Hasps:

1. Anodized aluminum hasp with erasable label surface.
2. Seven (7) by three (3) inches.

B. Valves:

1. Steel device preventing operation with lock-accepting shackle.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Install identifying devices after completion of coverings and painting.

3.2 PIPE IDENTIFICATION INSTALLATION

A. Identify all piping with plastic pipe markers.

B. Identify service, flow direction, and pressure.

C. Install in clear view and align with axis of piping.

D. Locate identification as follows:

1. On every straight run, including risers and drops.
2. Every twenty (20) feet on straight runs.
3. Adjacent to each valve and tee.
4. At each side of wall and floor penetrations.
5. At the underside of roof penetrations.
6. Not less than once in each room.

E. Install underground plastic pipe markers six (6) inches below finished grade, directly above buried pipe.

3.3 VALVE TAG INSTALLATION

A. Identify valves in main and branch piping with valve tags.

B. Install valve tags using corrosion resistant chain.

C. Number tags consecutively by location.

3.4 CEILING TACK INSTALLATION

A. Provide ceiling tacks to locate valves above T-bar type panel ceilings.

B. Locate in corner of ceiling panel closest to equipment.

3.5 NAMEPLATE INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

B. Identify all equipment with plastic nameplates.

C. Identify all disconnects provided by the contractor with nameplates.

3.6 LABEL INSTALLATION

A. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer.

B. Identify inline specialties and other small devices with labels.

3.7 LOCKOUT DEVICE INSTALLATION

A. Install lockout devices on all disconnects.

B. Install lockout devices on all circuit breakers when used as the primary disconnect.

C. Install lockout devices on all service valves to equipment.

END OF SECTION

SECTION 22 07 00

INSULATION FOR PLUMBING SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Pipe insulation.
2. Pipe insulation jackets.
3. Pipe insulation shields and inserts.

1.2 REFERENCES

A. ASTM International:

1. ASTM C547 – Standard Specification for Mineral Fiber Pipe Insulation.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data for the following:

1. Pipe insulation.
2. Pipe insulation jackets.
3. Pipe insulation shields and inserts.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data, manufacturer’s warranties, and operation and maintenance instructions for the following:

1. Pipe insulation.
2. Pipe insulation jackets.
3. Pipe insulation shields and inserts.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not install insulation and related products when ambient temperatures and conditions do not meet manufacturer’s requirements.

B. Maintain required temperature and humidity before, during, and after installation for at least twenty-four (24) hours.

PART 2 PRODUCTS

2.1 PIPE INSULATION

A. Mineral fiber: ASTM C547; rigid molded, noncombustible, formaldehyde free.

1. K-factor: Twenty-seven-one-hundredths (0.27) at seventy-five (75) degrees Fahrenheit.
2. Maximum service temperature: Eight hundred (800) degrees Fahrenheit.

3. Vapor retarder jacket: Kraft paper with glass fiber yarn and bonded to all-service jacket, secured with self-sealing longitudinal laps and butt strips or with outward clinch expanding staples and vapor retarder mastic.

2.2 PIPE INSULATION JACKETS

A. Polyvinyl chloride (PVC) plastic:

1. One-piece molded type fitting covers and sheet material.
2. Ten (10) mil with brush on welding adhesive.

B. Canvas:

1. Underwriters Laboratories, Inc. listed fabric.
2. Six (6) ounces per square yard, plain weave cotton treated with dilute fire-retardant lagging adhesive.

2.3 PIPE INSULATION SHIELDS AND INSERTS

A. Shields:

1. Twenty-two (22) gauge galvanized steel.

B. Inserts:

1. Cork or other high density insulating material, not less than six (6) inches long.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Verify piping and equipment has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

C. Neatly finish insulation at supports, protrusions, and interruptions.

D. Locate insulation and cover seams in least visible locations where not specified below.

E. Insulate complete systems conveying fluids below ambient temperature, including fittings, valves, unions, flanges, strainers, flexible connections, etc. Provide vapor barrier jackets for mineral fiber insulation.

F. Insulate complete systems conveying fluids above ambient temperature, including fittings, valves, unions, flanges, strainers, flexible connections, etc. Insulate flanges and unions with removable sections and jackets.

3.2 PIPING INSULATION INSTALLATION

A. Continue insulation vapor barrier through penetrations.

B. For exposed piping, finish with canvas jacket sized for finish painting. Provide PVC jacket and fitting covers in exposed locations in kitchens and mechanical rooms.

C. For buried piping, insulate only where insulation manufacturer recommends insulation product may be installed in trench, tunnel, or direct buried. Install factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one (1) mil aluminum foil sandwiched between three (3) layers of bituminous compound. Outer surface shall be faced with polyester film.

D. Insulate piping systems in accordance with the following:

PIPING SYSTEM	PIPE SIZE RANGE	INSULATION SIZE
Domestic Cold-Water Supply	½” – 1¼”	½”
Domestic Cold-Water Supply	1½” – 4”	1”
Domestic Hot Water Supply	½” – 1¼”	1”
Domestic Hot Water Supply	1½” – 4”	1½”
Domestic Hot Water Return	½” – 1¼”	1”
Domestic Hot Water Return	1½” – 4”	1½”

3.3 PIPE INSULATION SHIELD AND INSERT INSTALLATION

A. Provide shields on piping or equipment one-and-one-half (1-1/2) inches diameter or larger.

B. Install inserts on piping two (2) inches diameter or larger. Install between support shield and piping and under finish jacket.

END OF SECTION

SECTION 22 11 00
DOMESTIC WATER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Piping.
2. Valves.
3. Strainers.
4. Pressure gauges.
5. Thermometers.
6. Hydrants.
7. Recessed valve boxes.
8. Thermal expansion tanks.
9. Inline circulator pumps.
10. Water pressure booster systems.

1.2 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI Z21.22 – Relief Valves for Hot Water Supply Systems.

B. American Society of Mechanical Engineers (ASME):

1. ASME B16.15 – Cast Copper Alloy Threaded Fittings: Classes 125 and 250.
2. ASME B16.18 – Cast Copper Alloy Solder Joint Pressure Fittings.
3. ASME B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
4. ASME B40.1 – Pressure Gauges and Gauge Attachments.

C. ASSE International:

1. ASSE 1003 – Performance Requirements for Water Pressure Reducing Valves.
2. ASSE 1017 – Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems.

D. ASTM International:

1. ASTM E1 – Standard Specification for Liquid-in-Glass Thermometers.

E. American Water Works Association (AWWA):

1. AWWA C651 – Disinfecting Water Mains.

F. Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS):

1. MSS SP 67 – Butterfly Valves.
2. MSS SP 71 – Gray Iron Swing Check Valves, Flanged and Threaded Ends.

3. MSS SP 80 – Bronze Gate, Globe, Angle, and Check Valves.
4. MSS SP 110 – Ball Valves Threaded, Socket Welding, Solder Joint, Grooved, and Flared Ends.

G. NSF International:

1. NSF 61 – Drinking Water System Components – Health Effects.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:

1. Piping.
2. Valves.
3. Strainers.
4. Pressure gauges.
5. Thermometers.
6. Hydrants.
7. Recessed valve boxes.
8. Thermal expansion tanks.
9. Inline circulator pumps.
10. Water pressure booster systems.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data, manufacturer's product warranties, and operation and maintenance instructions for the following:

1. Piping.
2. Valves.
3. Strainers.
4. Pressure gauges.
5. Thermometers.
6. Hydrants.
7. Recessed valve boxes.
8. Thermal expansion tanks.
9. Inline circulator pumps.
10. Water pressure booster systems.

PART 2 PRODUCTS

2.1 PIPING

A. Copper Tubing: ASTM B88, Type L, drawn-temper (hard).

1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
2. Press Fittings: ASME B16.18, cast copper, or ASME B16.22, wrought copper and performance criteria of ASME b16.51, with EPDM rubber O-rings at each end.
3. Joints shall be one of the following:
   a. Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
   b. Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.
   c. Pressure-Seal-Joints, lead free, minimum 200-psig working pressure rating at 250 degrees F.

B. Water distribution pipe shall conform to NSF 61. All water distribution pipe and tubing shall have a minimum pressure rating of one hundred (100) psi at one-hundred-eighty (180) degrees Fahrenheit.

C. Pipe fittings shall be approved for installation with the piping material installed. All pipe fittings utilized in water supply systems shall also comply with NSF 61. The fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping.

2.2 VALVES

A. Ball:

1. Four (4) inches or less: MSS SP 110; 600 psi CWP; two-piece cast brass body; replaceable Teflon seats; full port; blowout proof stems; chrome-plated brass ball; threaded, soldered, or compression ends; locking lever handle operated.
2. Provide extended stems for valves in insulated piping.

B. Swing check:

1. Two (2) inches or less: MSS SP 80; class 125; 200 psi CWP; cast bronze body and cap; threaded, soldered or compression ends; Y-pattern swing type nitrile rubber disc.
2. Two-and-one-half (2-1/2) inches or more: MSS SP 71; class 125; 200 psi CWP; cast iron body, bronze mounted, and bolted bonnet; flanged or threaded ends; swing type nitrile rubber disc; nonasbestos gasket.

C. Spring-loaded check:

1. Two (2) inches or less: MSS SP 80; class 125; 200 psi CWP; cast bronze body and cap; threaded, soldered or compression ends; inline spring lift check; silent closing nitrile rubber disc; integral seat.
2. Two-and-one-half (2-1/2) inches or more: MSS SP 71; class 125; 200 psi CWP; cast iron body, bronze mounted, and bolted bonnet; flanged or threaded ends; wafer style; center guided bronze disc; stainless steel springs and screws.

D. Flow control:

1. Construction: Class 125; bronze body; union on inlet and outlet; temperature and pressure test plug on inlet and outlet; combination blow-down drain.
2. Calibration: Control flow within five (5) percent of selected rating; over operating pressure range of ten (10) times minimum pressure required for control; maximum minimum pressure five (5) psi.

E. Pressure relief:

1. ANSI Z21.22; bronze body; Teflon seat; stainless steel stem and springs; automatic; direct pressure actuated.

F. Temperature and pressure relief:

1. ANSI Z21.22; bronze body; Teflon seat; stainless steel stem and springs; automatic; direct pressure actuated; temperature relief maximum 210 degrees F; capacity ASME certified and labeled.

G. Master thermostatic mixing valves.

1. Valve: Chrome-plated cast brass body; programmable digital controller with integral pressure and temperature sensors, with connections to building automation system for monitoring and control; fully factory piped and assembled on a wall-mount rack frame, including test connections and valves.
2. Capacity: As specified in thermostatic mixing valve schedule on drawings.
3. Temperature actuated mixing valves, which are installed to reduce water temperatures to defined limits, shall comply with ASSE 1017.

H. All valves shall be of an approved type and compatible with the type of piping material installed in the system. Ball valves, gate valves, globe valves, and plug valves intended to supply drinking water shall meet the requirements of NSF 61.

2.3 STRAINERS

A. Two (2) inches or less: Class 150; 300 psi CWP; bronze body; Y-pattern with 1/32 inch stainless steel perforated screen; threaded, soldered or compression ends.

B. Two-and-one-half (2-1/2) inches to four (4) inches: Class 125; 200 psi CWP; cast iron body, bronze fitted; Y-pattern with 1/16-inch stainless steel perforated screen; flanged or threaded ends.

2.4 PRESSURE GAUGES

A. Gauge: ASME B40.1; with bourdon tube; rotary brass movement; brass socket; front calibration adjustment; black scale on white background.

1. Case: Cast aluminum.
2. Bourdon tube: Brass.
3. Dial size: four (4) inches diameter.
4. Mid-scale accuracy: One (1) percent.
5. Scale: Psi.
6. Pressure gauge taps:
   a. Needle valve: Brass, 1/4-inch NPT for 300 psi.
   b. Pulsation damper: Pressure snubber, brass with 1/4-inch NPT connections.

2.5 THERMOMETERS

A. Thermometer: ASTM E1; adjustable angle; red appearing mercury; lens front tube; cast aluminum case with enamel finish; cast aluminum adjustable joint with positive locking device.

1. Size: 7-inch scale.

2. Window: Clear Lexan plastic.
3. Stem: Brass, 3/4 inch NPT, 3-1/2 inch long.
4. Accuracy: Two (2) percent.
5. Calibration: Degrees F.

2.6 HYDRANTS

A. As specified in plumbing fixture schedule on drawings.

2.7 RECESSED VALVE BOXES

A. As specified in plumbing fixture schedule on drawings.

2.8 THERMAL EXPANSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME Section VIII; supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.

B. Accessories: Pressure gauge and air-charging fitting, tank drain; pre-charge to forty (40) psig.

C. Size: As specified in thermal expansion tank schedule on drawings.

2.9 INLINE CIRCULATOR PUMPS

A. Casing: Bronze rated for 125 psig working pressure with stainless steel rotor assembly.

B. Impeller: Bronze.

C. Shaft: Alloy steel with integral thrust collar and two, oil lubricated bronze sleeve bearings.

D. Seal: Carbon rotating against stationary ceramic seat.

E. Drive: Flexible coupling.

F. Performance: As specified in pump schedule on drawings.

G. Electrical characteristics: As specified in pump schedule on drawings.

PART 3 EXECUTION

3.1 PIPING INSTALLATION

A. Piping shall be neatly arranged – straight, parallel, or at right angles to walls – and cut accurately to established measurements.

B. Group piping whenever practical at common elevations.

C. Pipes shall be worked into place without springing or forcing.

D. Sufficient headroom shall be provided to enable the clearing of light fixtures, ductwork, sprinklers, aisles, passageways, windows, doors, and other openings.

E. Pipes shall not interfere with access to maintain equipment.

F. Pipes shall be clean, free of cuttings and foreign matter inside, and exposed ends shall be covered during site storage and installation. Split, bent, flattened, or otherwise damaged pipe or tubing shall not be used.

G. Sufficient clearance shall be provided from walls, ceilings, and floors to permit the welding, soldering, or connecting of joints and valves. No less than six (6) inches of clearance shall be provided.

H. Installation of pipe inside electrical equipment rooms, telecommunications or data rooms, elevator machine rooms, elevator hoistways, and stairwells is prohibited.

I. Piping systems shall not interfere with the proper operation and maintenance of safety or relief valves.

J. Means of draining the entire facility water distribution system shall be provided. A hose thread hydrant with vacuum breaker shall be placed at each low point in the system for this purpose. Constant grades to the low points shall be maintained for proper drainage. Piping shall be free of pockets due to changes in elevations.

K. Install brass male adapters each side of valves in copper piped system.

L. Install unions downstream of valves and at equipment or apparatus connections.

M. Provide access doors where union, valves, or similar inline pipe accessories are not accessible. Refer to section 22 01 00.

N. Sleeve pipes passing through partitions, walls, and floors. Refer to section 22 05 29.

O. Install firestopping at fire-rated construction perimeters and openings containing penetrating sleeves and piping. Refer to section 22 05 32.

P. Prepare exposed, unfinished pipe and fittings for finish painting. Refer to section 22 05 53.

Q. Water service pipe and the building sewer shall be separated by five (5) feet of undisturbed or compacted earth.

  1. Exceptions:

    a. The required separation distance shall not apply where the bottom of the water service pipe within five (5) feet of the sewer is a minimum of twelve (12) inches above the top of the highest point of the sewer and the pipe materials conform to Table 702.3 of the North Carolina Plumbing Code.

    b. Water service pipe is permitted to be located in the same trench with a building sewer, provided such sewer is constructed of materials listed in Table 702.2 of the North Carolina Plumbing Code.

    c. The required separation distance shall not apply where a water service pipe crosses a sewer pipe, provided the water service pipe is sleeved at least five (5) feet horizontally from the sewer pipe centerline on both sides of such crossing with pipe materials listed in Table 605.3, 702.2, or 702.3 of the North Carolina Plumbing Code.

R. Potable water service pipes shall not be located in, under, or above cesspools, septic tanks, septic tank drainage fields, or seepage pits.

S. The installation of a water service or water distribution pipe shall be prohibited in soil and ground water contaminated with solvents, fuels, organic compounds, or other detrimental materials causing permeation, corrosion, degradation, or structural failure of the piping material. Where detrimental conditions are suspected, a chemical analysis of the soil and ground water conditions shall be required to ascertain the acceptability of the water service or water distribution piping material for the specific installation. Where detrimental conditions exist, approved alternative materials or routing shall be required.

T. Joints between copper or copper-alloy pipe or fittings shall comply with the following:

  1. Soldered joints: Soldered joints shall be made in accordance with the methods of ASTM B828. All cut tube ends shall be reamed to the full inside diameter of the

tube end. All joint surfaces shall be cleaned. A flux conforming to ASTM B813 shall be applied. The joint shall be soldered with a solder conforming to ASTM B32. The joining of water supply piping shall be made with lead-free solders and fluxes. “Lead-free” shall mean a chemical composition equal to or less than 0.2-percent lead.

2. Threaded joints: Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

3.2 VALVE INSTALLATION

A. Provide temporary protective coating on cast iron and steel valves.

B. Install valves with stems upright or horizontal, not inverted.

C. Provide ball valves adjacent to equipment when functioning to isolate equipment.

D. Provide spring loaded check valves on discharge of water pumps.

E. Where water pressure within a building exceeds eighty (80) psi static, an approved water pressure reducing valve conforming to ASSE 1003 with strainer shall be installed to reduce the pressure in the building water distribution piping to eighty (80) psi static or less.

1. The pressure-reducing valve shall be designed to remain open to permit uninterrupted water flow in case of valve failure.

2. All water-pressure reducing valves, regulators, and strainers shall be so constructed and installed as to permit repair or removal of parts without breaking a pipeline or removing the valve and strainer from the pipeline.

F. Full open valves shall be installed in the following locations:

1. A full open valve shall be located either outside the building within five (5) feet of the foundation wall in a readily accessible valve box, in the crawlspace within three (3) feet of the crawlspace access door or within the building in a location where it may be accessed without the use of a ladder or a tool.

2. On the base of every water riser pipe.

3. On the water supply pipe to a pressurized water tank.

4. On the water supply pipe to every water heater.

G. Shutoff valves shall be installed in the following locations:

1. On the fixture supply to each plumbing fixture other than bathtubs and showers.

2. On the water supply to each appliance or mechanical equipment.

3. Each supply branch line serving more than one fixture shall have a shutoff valve installed so as to isolate all fixtures and all pieces of equipment supplied by the branch line. The shutoff valve shall be labeled and located as close to the connection to the supply main and riser as practical.

H. Access shall be provided to all full open valves and shutoff valves.

I. Service valves shall be identified. All other valves installed in locations that are not adjacent to the fixture or appliance shall be identified, indicating the fixture or appliance served. Refer to specification section 22 05 53.

3.3 STRAINER INSTALLATION

A. Strainers shall be installed such that the blowdown is perpendicular to the floor, wall, or ceiling through which access to the strainer is obtained.

B. Access shall be provided to all strainers.

3.4 WATER HAMMER ARRESTER INSTALLATION

A. A water hammer arrester shall be installed where quick-closing valves and metallic piping is used.

B. Install water hammer arresters on hot and cold-water supply piping as between the last two fixtures on the piping being served and as indicated in the drawings.

3.5 PRESSURE GAUGE INSTALLATION

A. Install one pressure gauge for each pump, locate taps before strainers and on suction and discharge of pump.

B. Install gauge taps in piping.

C. Install pressure gauges with pulsation dampers. Provide needle valve to isolate each gauge.

D. Provide instruments with scale ranges selected according to service with largest appropriate scale.

E. Install gauges in locations where they are easily read from normal operating level. Install vertical to forty-five (45) degrees off vertical.

F. Adjust gauges to final angle, clean windows, and lenses, and calibrate to zero.

3.6 THERMOMETER INSTALLATION

A. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than two-and-one-half (2-1/2) inches for installation of thermometer sockets. Allow clearance from insulation.

B. Provide instruments with scale ranges selected according to service with largest appropriate scale.

C. Install thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

D. Adjust thermometers to final angle, clean windows, and lenses, and calibrate to zero.

3.7 HYDRANT INSTALLATION

A. Install at mounting heights indicated in plumbing fixture schedule on drawings.

B. Coordinate installation of exterior wall hydrants with the general contractor so that each hydrant occupies space within a single course of masonry units.

3.8 THERMAL EXPANSION TANK INSTALLATION

A. Install as indicated in thermal expansion tank schedule on drawings and in accordance with the water heater detail(s) on drawings.

3.9 PUMP INSTALLATION

A. Provide pumps to operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within twenty-five (25) percent of midpoint of published maximum efficiency curve.

B. Support piping adjacent to pump so no weight is carried on pump casings.

C. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve, balancing valve, and shutoff valve on pump discharge.

D. Lubricate pumps before startup.

3.10 PROTECTION OF THE POTABLE WATER SUPPLY

A. Chemicals and other substances that produce either toxic conditions, taste, odor, or discoloration in a potable water system shall not be introduced into, or utilized in, such systems.

B. Piping that has been utilized for any purpose other than conveying potable water shall not be utilized for conveying potable water.

C. The interior surface of a potable water tank shall not be lined, painted, or repaired with any material that changes the taste, odor, color, or potability of the water supply when the tank is placed in, or returned to, service.

D. Water pumps, filters, softeners, tanks, and all other devices that handle or treat potable water shall be protected against contamination.

3.11 INSPECTION AND TESTING

A. Refer to specification section 22 01 00 for general inspection and testing requirements and performance requirements of test gauges.

B. Upon completion of a section of or the entire water supply system, the system, or portion completed, shall be tested and proved tight under a water pressure of not less than the working pressure of the system; or an air test of not less than one hundred (100) psi. This pressure shall be held for at least fifteen (15) minutes. The water utilized for tests shall be obtained from a potable source of supply.

3.12 STERILZATION OF THE DOMESTIC WATER SYSTEM

A. Permitted new or repaired potable water systems shall be purged of deleterious matter prior to neutralization.

B. 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.

C. 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. Calcium hypochlorite and water mixture.

    a. 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 shall first be made into a paste, then thinned into slurry, and injected or pumped into the system.

D. The system or any part thereof shall be filled with a water-chlorine solution containing a chlorine concentration and shall stand in the system for a duration from either of the following:

1. Chlorine concentration of at least fifty (50) parts per million and a duration of twenty-four (24) hours.

2. Chlorine concentration of at least two hundred (200) parts per million and a duration of three (3) hours.

E. During the chlorination process all valves and accessories shall be independently and manually operated at least twice.

F. 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. Spent chlorinated water shall be disposed of in an environmentally responsible procedure.

G. Water supply shall not be placed into service until bacteriological test results are found to be satisfactory and the water meets Environmental Protection Agency quality standards for drinking water.

H. The contractor shall submit samples of the system water to a competent laboratory for analysis. Laboratory tests of the water shall be paid for by the contractor. The water test report shall be submitted to the professional for review and approval.

I. After acceptance by the professional, the water test report shall be submitted by the contractor to the owner and authority having jurisdiction prior to sending a request for final acceptance and occupancy permit.

END OF SECTION

SECTION 22 13 00

SANITARY WASTE AND VENT SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Underground sanitary waste and vent piping.
2. Aboveground sanitary waste and vent piping.
3. Valves.
4. Floor drains.
5. Floor sinks.
6. Cleanouts.
7. Interceptors.

1.2 REFERENCES

A. ASTM International:

1. ASTM A74 – Standard Specification for Cast Iron Soil Pipe and Fittings.
2. ASTM A888 – Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
3. ASTM B152 – Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar.
4. ASTM C564 – Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
5. ASTM C1540 – Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
6. ASTM C1563 – Standard Test Method for Gaskets for Use in Connection with Hub and Spigot Cast Iron Soil Pipe and Fittings for Sanitary Drain, Waste, Vent, and Storm Piping Applications.
7. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
8. ASTM D2564 – Standard Specification for Solvent Cements for Polyvinyl Chloride (PVC) Plastic Piping Systems.
9. ASTM D2665 – Standard Specification for Polyvinyl Chloride (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
10. ASTM D2855 – Standard Practice for Making Solvent Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings.
11. ASTM F656 – Standard Specification for Primers for Use in Solvent Cement Joints of Polyvinyl Chloride (PVC) Plastic Pipe and Fittings.

B. Cast Iron Soil Pipe Institute (CISPI):

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 – Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:

1. Underground sanitary waste and vent piping.
2. Aboveground sanitary waste and vent piping.
3. Valves.
4. Floor drains.
5. Floor sinks.
6. Cleanouts.
7. Interceptors.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data, manufacturer's warranties, and operation and maintenance instructions for the following:

1. Underground sanitary waste and vent piping.
2. Aboveground sanitary waste and vent piping.
3. Valves.
4. Floor drains.
5. Floor sinks.
6. Cleanouts.
7. Interceptors.

PART 2 PRODUCTS

2.1 UNDERGROUND SANITARY WASTE AND VENT PIPING

A. Cast iron pipe:

1. Pipe:
   a. Hub and spigot: ASTM A74.
2. Fittings:
   a. Hub and spigot: ASTM A74.
3. Joints:
   a. Hub and spigot:
      1) Compression gasket: ASTM C564, ASTM C1563.

B. Pipe fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping. Threaded drainage pipe fittings shall be of the recessed drainage type.

C. The following types of joints and connections shall be prohibited.

1. Cement or concrete joints.
2. Mastic or hot pour bituminous joints.
3. Joints made with fittings not approved for the specific installation.
4. Joints between different diameter pipes made with elastomeric O-rings.
5. Solvent cement joints between different types of plastic pipe.
6. Saddle type fittings.

2.2 ABOVEGROUND SANITARY WASTE AND VENT PIPING

A. Cast iron pipe:

1. Pipe:
   a. Hubless: ASTM A888, CISPI 301.
2. Fittings:
   a. Hubless: ASTM A888, CISPI 301.
3. Joints:
   a. Hubless shielded couplings: ASTM C564, CISPI 310.
      1) Heavy duty: ASTM C1540.

B. Pipe fittings shall not have ledges, shoulders, or reductions capable of retarding or obstructing flow in the piping. Threaded drainage pipe fittings shall be of the recessed drainage type.

C. The following types of joints and connections shall be prohibited.

1. Cement or concrete joints.
2. Mastic or hot pour bituminous joints.
3. Joints made with fittings not approved for the specific installation.
4. Joints between different diameter pipes made with elastomeric O-rings.
5. Solvent cement joints between different types of plastic pipe.
6. Saddle type fittings.

2.3 FLOOR DRAINS

A. As specified in plumbing fixture schedule on drawings.

2.4 FLOOR SINKS

A. As specified in plumbing fixture schedule on drawings.

2.5 CLEANOUTS

A. Cleanout plugs shall be brass or plastic, or other approved materials. Brass cleanout plugs shall be utilized with metallic drain, waste, and vent piping only, and shall conform to ASTM A74. Cleanouts with plate-style access covers shall be fitted with corrosion-resistant fasteners.

B. As specified in plumbing fixture schedule on drawings.

PART 3 EXECUTION

3.1 PIPING INSTALLATION

A. Fittings shall be installed to guide sewage and waste in the direction of flow. Change in direction shall be made by fittings installed in accordance with the following table. Change in direction by combination fittings, side inlets, or increasers shall be installed in accordance with the following table based on the pattern of flow created by the fitting.

TYPE OF FITTING PATTERN	CHANGE IN DIRECTION		
	HORIZONTAL TO VERTICAL	VERTICAL TO HORIZONTAL	HORIZONTAL TO HORIZONTAL
Sixteenth bend	X	X	X
Eighth bend	X	X	X
Sixth bend	X	X	X
Quarter bend	X	X[3,5]	X[4]
Short sweep	X	X[2]	X[1]
Long sweep	X	X	X
Sanitary tee	X		
Wye	X	X	X
Combination wye and eighth bend	X	X	X

1. The fittings shall only be permitted for a two (2) inch or smaller sink or lavatory fixture drain.
2. Two (2) inches and larger.
3. May be used only within twelve (12) inches below water closet flange measured to centerline of the quarter bend.
4. This fitting shall only be permitted to be used as the first fitting directly behind the fixture for drains two (2) inches and smaller, except clothes washers.
5. The heel inlet connection of a quarter bend may be used as a wet or dry vent if the heel inlet connection of the quarter bend is located in the vertical position. The heel or side inlet connection may be used as a wet vent if the quarter bend is located directly below a water closet or other fixture with one integral trap.

B. Heel inlet quarter bends shall be an acceptable means of connection, except where the quarter bend serves a water closet. A low heel inlet shall not be used as a wet vented connection. Side inlet quarter bends shall be an acceptable means of connection for drainage, wet venting, and stack venting arrangements.

C. Direct connection of a steam exhaust, blowoff, or drip pipe shall not be made with the building drainage system. Wastewater when discharged into the building drainage system shall be at a temperature not higher than 140 °F. When higher temperatures exist, approved cooling methods shall be provided.

D. Exposed soil or waste piping shall not be installed above any working, storage, or eating surfaces in food service establishments.

E. Water service pipe and the building sewer shall be separated by five (5) feet of undisturbed or compacted earth.

1. Exceptions:

a. The required separation distance shall not apply where the bottom of the water service pipe within five (5) feet of the sewer is a minimum of twelve (12) inches above the top of the highest point of the sewer and the pipe materials conform to Table 702.3 of the North Carolina Plumbing Code.

b. Water service pipe is permitted to be located in the same trench with a building sewer, provided such sewer is constructed of materials listed in Table 702.2 of the North Carolina Plumbing Code.

c. The required separation distance shall not apply where a water service pipe crosses a sewer pipe, provided the water service pipe is sleeved at least five (5) feet horizontally from the sewer pipe centerline on both sides of such crossing with pipe materials listed in Table 605.3, 702.2, or 702.3 of the North Carolina Plumbing Code.

F. Horizontal drainage piping shall be installed in uniform alignment at uniform slopes. The minimum slop of a horizontal drainage pipe shall be in accordance with the following:

1. Pipes sized two-and-one-half (2-1/2) inches or less: one-quarter (1/4) inch per foot.

2. Pipes sized (3) three to six (6) inches: one-eighth (1/8) inch per foot.

3. Slope all grease waste piping at one-quarter (1/4) inch per foot.

G. The size of drainage piping shall not be reduced in size in the direction of flow.

H. Horizontal branches shall connect to the bases of stacks at a point located not less than ten (10) times the diameter of the drainage stack downstream from the stack. Horizontal branches shall connect to horizontal stack offsets at a point located not less than ten (10) times the diameter of the drainage stack downstream of the upper stack.

I. In the installation or removal of any part of a drainage system, dead ends shall be prohibited. Cleanout extensions and approved future fixture drainage piping shall not be considered as dead ends.

J. Joints between cast iron pipe or fittings shall comply with the following:

1. Compression gasket joints: Compression gaskets for hub and spigot pipe and fittings shall conform to ASTM C564 and shall be tested to ASTM C1563. Gaskets shall be compressed when the pipe is fully inserted.

2. Mechanical joint couplings: Mechanical joint couplings for hubless pipe and fittings shall comply with CISPI 310, ASTM C1277, or ASTM C1540. The elastomeric sealing sleeve shall conform to ASTM C564 and shall be provided with a center stop. Mechanical joint couplings shall be installed in accordance with the manufacturer’s instructions.

K. Joints between polyvinyl chloride (PVC) plastic pipe or fittings shall comply with the following:

1. Solvent cementing: Joint surfaces shall be clean and free of moisture. A purple primer or an ultraviolet purple primer that conforms to ASTM F656 shall be applied. When an ultraviolet primer is used, the installer shall provide an ultraviolet light to the inspector to be used during the inspection. Solvent cement not purple in color and conforming to ASTM D2564 shall be applied to all joint surfaces. The joint shall be made while the cement is wet and shall be in accordance with ASTM D2855. Solvent cement joints shall be permitted above or below ground.

L. Outdoor vent extensions shall comply with the following:

1. Every building in which plumbing is installed shall have at least one (1) stack the size of which is not less than one-half (1/2) of the required diameter of the building drain, and not less than two (2) inches in diameter. Such stack shall run undiminished in size and as directly as possible from the building drain through to the open air or to a vent header that extends to the open air.

2. Vent stacks or stack vents shall extend outdoors and terminate to open air.

M. Vent terminals shall comply with the following:

1. All open vent pipes that extend through a roof shall be terminated at least six (6) inches above the roof, except that where a roof is used by the public or tenants for any purpose, the vent extensions shall be run at least seven (7) feet above the roof.

2. The juncture of each vent pipe with the roof line shall be made water-tight by an approved flashing.

a. Sheet copper for vent pipe flashing shall conform to ASTM B152 and shall weigh not less than eight (8) ounces per square foot.

b. Sheet lead for vent pipe flashings shall weight not less than three (3) pounds per square foot for field-constructed flashings and not less than two-and-one-half (2.5) pounds per square foot for prefabricated flashings.

3. Vent terminals shall not be used a flag pole or to support flag poles, television aerials, or similar items, except when the piping has been anchored in an approved manner.

4. An open vent terminal from a drainage system shall not be located directly beneath any door, operable window, or other air intake opening of the building or of an adjacent building or property line, and any such vent terminal shall not be within ten (10) feet horizontally of such an opening unless it is at least two (2) feet above the top of such opening.

N. Vent connections shall comply with the following:

1. All individual, branch, and circuit vents shall connect to a vent stack, stack vent, air admittance valve, or extend to the open air.

2. All vent and branch vent pipes shall be so graded and connected as to drain back to the drainage pipe by gravity.

3. Every dry vent connecting to a horizontal drain shall connect above the centerline of the horizontal drain pipe.

4. Every dry vent shall rise vertically to a minimum of six (6) inches above the flood level rim of the highest trap or trapped fixture being vented.

   a. Exception: When vents for interceptors and isolated floor drains are not located near an adjacent wall, the vent must rise six (6) inches vertically before turning horizontally and continuing to the nearest wall. A cleanout the same size as the vent shall be provided.

5. A connection between a vent pipe and a vent stack or stack vent shall be made at least six (6) inches above the flood level rim of the highest fixture served by the vent. Horizontal vent pipes forming branch vents, relief vents, or loop vents shall be at least six (6) inches above the flood level rim of the highest fixture served.

O. Fixture vents shall comply with the following:

1. Each fixture trap shall have a protecting vent located so that the slope and the developed length in the fixture drain from the trap weir to the vent fitting are as indicated in Table 906.1 of the North Carolina Plumbing Code.

2. The total fall in a fixture drain due to pipe slope shall not exceed the diameter of the fixture drain, nor shall the vent connection to a fixture drain, except for water closets, be below the weir of the trap.

3. A vent shall not be installed within two (2) pipe diameters of the trap weir.

P. Each trap and trapped fixture is permitted to be provided with an individual vent. The individual vent shall connect to the fixture drain of the trap or trapped fixture being vented.

3.2 FLOOR DRAIN INSTALLATION

A. Coordinate the final location of all floor drains dedicated to serving equipment with the equipment provider prior to installation.

B. Floor drains shall be installed with tops and strainers level with the floor slab.

3.3 FLOOR SINK INSTALLATION

A. Coordinate the final location of all floor sinks dedicated to serving equipment with the equipment provider prior to installation.

B. Floor sinks shall be installed with tops and strainers level with the floor slab.

3.4 CLEANOUT INSTALLATION

A. Plugs shall have raised square or countersunk square heads. Countersunk heads shall be installed where raised heads are a trip hazard.

B. Cleanouts shall be located in accordance with the following:

1. All horizontal drains shall be provided with cleanouts located not more than one-hundred (100) feet apart.

2. One cleanout shall be required for every four (4) horizontal forty-five (45) degree changes located in series. A long sweep bend is equivalent to two (2) forty-five (45) degree bends.

3. A cleanout shall be provided at the base of each waste or soil stack.

4. There shall be a cleanout at the junction of the building drain and the building sewer. The cleanout shall be outside the building wall and shall be brought up to the finished ground level. An approved two-way cleanout is allowed to be used at this location to serve as a required cleanout for both the building drain and building sewer.

a. The cleanout at the junction of the building drain and building sewer shall not be required if the cleanout on a three (3) inch or larger diameter waste stack is located within a developed length of not more than fifteen (15) feet from the building drain and building sewer connections and is extended to the outside of the building.

C. Cleanout plugs shall not be covered with cement, plaster, or any other permanent finish material. Where it is necessary to conceal a cleanout or to terminate a cleanout in an area subject to vehicular traffic, the covering plate, access door, or cleanout shall be of an approved type designed and installed for this purpose.

D. Every cleanout shall be installed to open to allow cleaning in the direction of flow of the drainage piping or at right angles thereto.

E. Cleanouts shall be the same nominal size of the pipe they serve up to four (4) inches. For pipes larger than four (4) inches nominal size, the minimum size of the cleanout shall be four (4) inches.

F. Cleanouts on six (6) inch and smaller pipes shall be provided with a clearance of not less than eighteen (18) inches for rodding.

G. Access shall be provided to all cleanouts.

H. Each horizontal drainage pipe shall be provided with a clean out at the upstream end of the pipe.

1. The following plumbing arrangements are acceptable in lieu of the upstream cleanout:

a. P-traps connected to the drainage piping with slip joints or ground joint connections.

b. P-traps into which floor drains, shower drains, or tub drains with removable strainers discharge.

c. P-traps into which straight through type waste and overflow discharge with the overflow connecting to the top of the tee.

d. P-traps into which residential washing machines discharge.

e. Test tees or cleanouts in a vertical pipe.

f. Cleanout near the junction of the building drain and the building sewer which may be rodded in both directions.

g. Water closets for the water closet fixture drain only.

h. Cast iron cleanout sizing shall be in accordance with ASTM A74 for hub and spigot fittings or CISPI 301 for hubless fittings.

3.5 INSPECTION AND TESTING

A. Refer to specification section 22 01 00 for general inspection and testing requirements and performance requirements of test gauges.

B. Drainage and vent water test:

1. A water test shall be applied to the drainage system within the building either in its entirety or in sections.

2. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system shall be filled with water to the point of overflow.

3. If the system is tested in sections, each opening shall be tightly plugged except the highest openings of the section under test, and each section shall be filled with water, but no section shall be tested with less than a ten (10) foot head of water.

4. In testing successive sections, at least the upper ten (10) feet of the next preceding section shall be tested so that no joint or pipe in the building, except the uppermost ten (10) feet of the system shall have been submitted to a test of less than a ten (10) foot head of water.

5. This pressure shall be held for at least fifteen (15) minutes. Then system shall then be tight at all points.

C. Drainage and vent final test:

1. The final test of the completed drainage and vent systems shall be visual and in sufficient detail to determine compliance with the provisions of the contract documents.

END OF SECTION

SECTION 22 33 00

ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Storage type water heaters.

1.2 REFERENCES

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ASME International:

1. ASME PTC 25 – Pressure Relief Devices.
2. ASME Section VIII – Boiler and Pressure Vessel Code - Pressure Vessels.

C. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data for the following:

1. Storage type water heaters.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer's data, manufacturer's warranties, and operation and maintenance instructions for the following:

1. Storage type water heaters.

PART 2 - PRODUCTS

2.1 STORAGE TYPE WATER HEATERS

A. Type: Factory-assembled and wired, electric, vertical storage.

B. Capacity: As indicated in water heater schedule on drawings.

C. Tank: Glass-lined welded steel; four (4) inches diameter inspection port, thermally insulated with minimum two (2) inches polyurethane encased in corrosion-resistant steel jacket; baked-on enamel finish.

D. Controls: Automatic immersion water thermostat; externally adjustable temperature range, flanged or screw-in nichrome elements, high temperature limit thermostat.

E. Accessories: Brass water connections and dip tube, drain valve, magnesium anode, and ASME rated temperature and pressure relief valve.

F. Heating elements: Flange-mounted immersion elements; individual elements sheathed with corrosion-resistant metal alloy.

G. Electrical characteristics: As indicated in water heater schedule on drawings.

PART 3 - EXECUTION

3.1 STORAGE TYPE WATER HEATER INSTALLATION

A. Maintain manufacturer's recommended clearances.

B. Install discharge piping from relief valves and drain valves as indicated in detail on drawings.

C. Install water heater trim and accessories furnished loose for field mounting.

D. Install electrical devices furnished loose for field mounting.

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Flush valve water closets.
2. Urinals.
3. Lavatories.
4. Electric water coolers.
5. Sinks.
6. Showers.
7. Custodial sinks.
8. Recessed valve boxes for automatic clothes washers.
9. ADA compliant insulation kit.

1.2 REFERENCES

A. American National Standards Institute:

1. ANSI A117.1 – Accessible and Usable Buildings and Facilities.

B. United States Department of Justice:

1. ADA Standards for Accessible Design.

1.3 SUBMITTALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data for the following:

1. Flush valve water closets.
2. Urinals.
3. Lavatories.
4. Electric water coolers.
5. Sinks.
6. Showers.
7. Custodial sinks.
8. Recessed valve boxes for automatic clothes washers.
9. ADA compliant insulation kit.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Refer to specification section 22 01 05 for submittal requirements, definitions, and procedures.

B. Submit manufacturer’s data, manufacturer’s warranties, and operation and maintenance instructions for the following:

1. Flush valve water closets.
2. Urinals.
3. Lavatories.
4. Electric water coolers.
5. Sinks.
6. Showers.
7. Custodial sinks.
8. Recessed valve boxes for automatic clothes washers.
9. ADA compliant insulation kit.

PART 2 PRODUCTS

2.1 FLUSH VALVE WATER CLOSETS

A. As specified in plumbing fixture schedule on drawings.

2.2 URINALS

A. As specified in plumbing fixture schedule on drawings.

2.3 LAVATORIES

A. As specified in plumbing fixture schedule on drawings.

2.4 ELECTRIC WATER COOLERS

A. As specified in plumbing fixture schedule on drawings.

2.5 SINKS

A. As specified in plumbing fixture schedule on drawings.

2.6 SHOWERS

A. As specified in plumbing fixture schedule on drawings.

2.7 CUSTODIAL SINKS

A. As specified in plumbing fixture schedule on drawings.

2.8 AUTOMATIC CLOTHES WASHERS

A. Fixtures shall be provided by others. The contractor shall provide final connections to the fixture.

B. As specified in plumbing fixture schedule on drawings.

2.9 ADA COMPLIANT INSULATION KIT

A. Safety covers conforming to ANSI A117.1 and consisting of insulation kit of molded closed cell antimicrobial vinyl construction, minimum 1/8-inch thick, white color, for insulating tailpiece, P-trap, valves, and supply piping. Furnish with cleanout angle valve access covers.

PART 3 EXECUTION

3.1 PREINSTALLATION

A. Verify walls and floor finishes are prepared and ready for installation of fixtures.

B. Confirm millwork is constructed with adequate provision for installation of countertop lavatories and sinks.

C. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough in and installation.

D. Rough-in fixture piping connections in accordance with minimum sizes indicated in plumbing fixture schedule for each particular fixture.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. For ADA compliant fixtures, installation shall comply with the requirements of the latest edition of the Department of Justice’s document *ADA Standards for Accessible Design*. These guidelines shall apply unless superseded by more stringent state or local requirements.

B. The supply lines and fittings for every plumbing fixture shall be installed so as to prevent backflow.

C. Plumbing fixtures shall be installed so as to afford easy access for cleaning both the fixture and the area around the fixture.

D. Fixtures shall be set level and in proper alignment with reference to adjacent walls.

E. Joints formed where fixtures come in contact with walls or floors shall be sealed as indicated.

F. Slip-joint connections are prohibited.

3.3 WATER CLOSET INSTALLATION

A. Connections between the drain and wall-hung water closets shall be made with an approved extension nipple or horn adaptor. The water closet shall be bolted to the hanger with corrosion-resistant bolts or screws. Joints shall be sealed with an approved elastomeric gasket, flange-to-fixture connection complying with ASME A112.4.3, or an approved setting compound. Wall-hung water closets shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system.

B. Seal fixture connection to wall with white acrylic caulk.

C. A water closet shall not be set closer than fifteen (15) inches from its center to any side wall, partition, vanity, or other obstruction, or closer than thirty (30) inches center-to-center between adjacent fixtures. There shall be at least twenty-one (21) inches clearance in front of the water closet to any wall, fixture, or door.

3.4 URINAL INSTALLATION

A. Connect fixture securely so that the carrier bears the entire weight of the fixture. None of the load shall be transferred to the piping system. Seal fixture connection to wall with white acrylic caulk.

B. A urinal shall not be set closet than fifteen (15) inches from its center to any side wall, partition, vanity, or other obstruction, or closer than thirty (30) inches center-to-center between adjacent fixtures. There shall be at least twenty-one (21) inches clearance in front of the urinal to any wall, fixture, or door.

3.5 LAVATORY INSTALLATION

A. Connect fixture securely so that the carrier bears the entire weight of the fixture. None of the load shall be transferred to the piping system. Seal fixture connection to wall with white acrylic caulk.

B. Install each fixture with trap easily removable for servicing and cleaning.

C. A lavatory shall not be set closet than fifteen (15) inches from its center to any side wall, partition, vanity, or other obstruction, or closer than thirty (30) inches center-to-center between adjacent fixtures. There shall be at least twenty-one (21) inches clearance in front of the lavatory to any wall, fixture, or door.

3.6 ELECTRIC WATER COOLER INSTALLATION

A. Connect fixture securely so that the mounting bracket bears the entire weight of the fixture. None of the load shall be transferred to the piping system. Seal fixture connection to wall with white acrylic caulk.

B. Install each fixture with filter easily removable for replacement.

C. Adjust stops or valves for intended to control water flow rate to fixtures without splashing, noise, or overflow.

3.7 SINK INSTALLATION

A. Connect fixture securely so that the countertop bears the entire weight of the fixture. None of the load shall be transferred to the piping system. Seal fixture connection to countertop with seal of white putty, white acrylic caulk, or concealed vinyl gasket.

B. Install each fixture with trap easily removable for servicing and cleaning.

3.8 SHOWER INSTALLATION

A. Install shower trim in accordance with the architectural plans.

3.9 CUSTODIAL SINK INSTALLATION

A. Basin shall be set in a bed of mortar and allowed to set before pipe connection is made. Waste outlet connection to piping shall be made with threaded fittings. When installed on an above grade floor, install fixture with trap easily removable for servicing and cleaning.

3.10 AUTOMATIC CLOTHES WASHER INSTALLATION

A. Confirm that the water supply connection is protected against backflow by an integral air gap prior to installation. Where the fixture does not have an integral air gap, provide a backflow preventer in accordance with the North Carolina Plumbing Code.

B. Securely support valve box from structural members on both sides.

3.11 ADA COMPLIANT INSULATION KIT INSTALLATION

A. Install on each lavatory or sink with exposed piping, including those that are not specified as ADA compliant fixtures.

B. Installation shall allow for access to cleanout plugs and valves without removal of the entire insulation kit.

END OF SECTION

SECTION 23 05 00

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 bench marks. 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

B. 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.

C. 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.

D. 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: Refer to mechanical drawings for Coordination Drawing requirements.

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, pudding 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 23 31 13 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 electrical components shall be U.L. listed and labeled.

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. Boilers
2. Chillers
3. DDC Control Systems
4. Air Handlers
5. Heat Transfer Package

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) Boilers – 1 day (8 hours)
2) Chillers – 1 day (8 hours)

a) (2) attendees shall be awarded offsite training to selected manufacturers chiller training school all expenses are included as a part of the project costs

3) DDC Control Systems - 2 days (16 hours)
4) Air Handlers - 1 day (8 hours)
5) Heat Transfer Package - 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

SECTION 23 05 13

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 in NEMA MG 1.

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. Manufacturers

a. The manufacturer of the AC drive shall be a certified ISO 9001 quality facility. Yaskawa, ABB, Danfoss (Graham), Eaton, 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 provide a harmonic analysis showing compliance with IEEE-519.

      iii. The AC drive shall have the Hand/Off/Auto function.

      iv. 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.

      v. 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.

vi. The AC drive shall have common control in both drive and bypass modes.

vii. Each AC drive shall have M.O.V. lightning protection.

viii. The AC drive shall have safety interlocks for all modes of operation.

ix. 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 ad/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

SECTION 23 05 19

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.

B. Related Sections:
1. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.
2. Division 23 Section "Facility Natural-Gas Piping" for gas 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 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

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Iron ball valves.
2. Iron, single-flange butterfly valves.
3. Iron, grooved-end butterfly valves.
4. High-performance butterfly valves.
5. Bronze swing check valves.
6. Iron swing check valves.
7. Iron swing check valves with closure control.
8. Iron, grooved-end swing-check valves.
9. Iron, center-guided check valves.
10. Iron, plate-type check valves.
11. Bronze gate valves.
12. Iron gate valves.
13. Bronze globe valves.
14. Iron globe valves.
15. Lubricated plug valves.
16. Eccentric plug valves.

B. Related Sections:
1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

1.4 SUBMITTALS

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

1.5 ACCEPTABLE MANUFACTURERS

A. All valves shall be manufactured in the USA.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Valve Co.
2. Cameron
3. Conbraco Industries.
4. Crane Co.
5. Hammond Valve
6. Milwaukee Valve Co.
7. NIBCO Inc.
8. Powell Valves
9. Watts Regulator Co

1.6 QUALITY ASSURANCE

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug-valve head.

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

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

F. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

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

2.2 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:
1. Description:
    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 175 psig.
    c. Body Material: Coated, ductile iron.
    d. Stem: Two-piece stainless steel.
    e. Disc: Coated, ductile iron.
    f. Seal: EPDM.

2.3 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:
1. Description:
    a. Standard: MSS SP-80, Type 3.
    b. CWP Rating: 300 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B 62, bronze.
    e. Ends: Threaded.
    f. Disc: Bronze.

2.4 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
1. Description:
    a. Standard: MSS SP-71, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Design: Clear or full waterway.
    e. Body Material: ASTM A 126, gray iron with bolted bonnet.
    f. Ends: Flanged.
    g. Trim: Bronze.
    h. Gasket: Asbestos free.

2.5 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
1. Description:
    a. Standard: MSS SP-71, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.

d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

2.6 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:
1. Description:
a. CWP Rating: 300 psig.
b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.7 IRON, CENTER-GUIDED CHECK VALVES

A. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
1. Description:
a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
e. Style: Compact wafer.
f. Seat: EPDM or NBR.

2.8 IRON, PLATE-TYPE CHECK VALVES

A. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:
1. Description:
a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
f. Seat: EPDM or NBR.

2.9 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:
1. Description:
a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.

2.10 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves:
1. Description:
a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.

c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.11 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Bronze Disc:
1. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

2.12 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:
1. Description:
a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

2.13 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
1. Description:
a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short.
f. Plug: Cast iron or bronze with sealant groove.

2.14 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.
1. Description:
a. Standard: MSS SP-108.
b. CWP Rating: 175 psig minimum.
c. Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
d. Bearings: Oil-impregnated bronze or stainless steel.
e. Ends: Flanged.
f. Stem-Seal Packing: Asbestos free.
g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

C. Install valves in horizontal piping with stem at or above center of pipe.

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

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

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling Service except Steam: Globe, ball, or butterfly valves.
   4. Throttling Service, Steam: Globe or butterfly valves.
   5. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
4. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER, CONDENSER WATER AND HOT WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Ball Valves: Three piece, full port, brass or bronze with brass trim.
2. Bronze Swing Check Valves: Class 150, bronze disc.
3. Bronze Gate Valves: Class 150, NRS, bronze.
4. Bronze Globe Valves: Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
3. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, NBR seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. High-Performance Butterfly Valves: Class 150, single flange.
6. Iron Swing Check Valves: Class 125, metal seats.
7. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
8. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
9. Iron, Center-Guided Check Valves: Class 150, compact-wafer, resilient seat.
10. Iron, Plate-Type Check Valves: Class 150; single plate; resilient seat.
11. Iron Gate Valves: Class 125, OS&Y.
12. Iron Globe Valves: Class 125.
13. Lubricated Plug Valves: Class 125, flanged.
14. Eccentric Plug Valves: 175 CWP, resilient seating.

END OF SECTION

SECTION 23 05 29

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.
4. Powder-actuated fastener systems.

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

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. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, 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 powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. 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 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger 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

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Freestanding and restrained spring isolators.
   4. Housed spring mounts.
   5. Spring hangers.
   6. Spring hangers with vertical-limit stops.
   7. Seismic snubbers.
   8. Restraining braces and cables.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.4 PERFORMANCE REQUIREMENTS

A. The Mechanical Contractor shall be responsible for providing restraints to resist the earthquake effects on the mechanical system. The requirements for these restraints are found in the North Carolina State Building Code and ASCE 7.

B. The Mechanical Contractor shall refer to the latest edition of the "Seismic Restraint Manual Guidelines for Mechanical System" published by SMACNA for guidelines to determine the correct restraints for sheet metal ducts, piping, and conduit, etc.

C. The Mechanical Contractor shall retain the services of a Professional Structural Engineer registered in the State of North Carolina to design seismic restraint elements required for this project. The engineer's computations, bearing his professional seal, shall accompany shop drawings which show Code compliance. Computations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment systems, and assemblies.

D. The professional engineer retained by the Mechanical Contractor for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation. This Engineer shall provide in writing verification of compliance with the approved seismic submittal. This verification shall bear the Engineer's professional seal. Job site inspection by other than this Engineer is not acceptable. This engineer shall also be responsible for any required special inspections and associated documentation related to seismic restraints.

E. Seismic-Restraint Loading:
1. Site Class as Defined in the NC State Building Code (Chapter 16) and ASCE 7, as determined by the project Structural Engineer of record.
2. Assigned Seismic Use Group or Building Category as Defined in the NC State Building Code (Chapter 16) and ASCE 7.
   a. Component Importance Factor.
   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-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. Interlocking Snubbers: 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 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, seismic restraints, and for designing vibration isolation bases.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and

values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By 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 HVAC piping and equipment 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.

F. Review of the seismic design and shop drawings by the Engineer/Architect or his agent shall not relieve the Contractor of his responsibility to comply with the seismic or any other requirements of the North Carolina State Building Code, Section 1607.

1.6 QUALITY ASSURANCE

A. The professional Engineer retained by the Mechanical Contractor for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation. This Engineer shall provide in writing verification of compliance with the approved seismic submittal. This verification shall bear the Engineer's professional seal. Job site inspection by other than this Engineer is not acceptable.

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.

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. Kinetics Noise Control.
2. Mason Industries.

3. Vibration Eliminator Co., Inc.
4. Vibration Isolation.
5. Vibration Mountings & Controls, Inc.

B. Pads: Arranged 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.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. 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.

F. 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.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
  1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
  2. Base: Factory drilled for bolting to structure.
  3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

H. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
  1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

I. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
  1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
  8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

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. Mason Industries.
  2. Vibration Eliminator Co., Inc.
  3. Vibration Isolation.
  4. Vibration Mountings & Controls, Inc.

2.3 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.
   2. Hilti, Inc.
   3. Kinetics Noise Control.
   4. Mason Industries.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by 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. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

D. 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.

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

F. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

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

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

K. Adhesive Anchor Bolts: 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.

2.4 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 Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:
1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

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

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

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

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection 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.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

SECTION 23 05 53

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, or 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.

PART 3 - EXECUTION

3.1 PREPARATION

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

C. Major mechanical equipment shall include:

   a. Air Handlers
   b. All AC units and heat pump units (split or packaged, water or air cooled)
   c. Boilers
   d. Pumps
   e. Fans

f. Expansion Tanks
g. Air Separators
h. Cooling towers

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. Condenser-Water Piping:
a. Background Color: Green.
b. Letter Color: White.
2. Heating Water Piping:
a. Background Color: Yellow.
b. Letter Color: Black.
3. 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. Chilled Water: 2 inches, round.
b. Refrigerant: 2 inches, round.
c. Hot Water: 2 inches, round.
d. Gas: 2 inches, round.
2. Valve-Tag Color:
a. Chilled Water: Natural.
b. Refrigerant: Natural.
c. Hot Water: Natural.
d. Gas: Natural.
3. Letter Color:
a. Chilled Water: Black.
b. Refrigerant: Black.
c. Hot Water: Black.
d. Gas: Black.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 23 05 93

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. Hydronic Piping Systems:

    a. Constant-flow systems.
    b. Variable-flow systems.
    c. Primary-secondary systems.

3. HVAC equipment quantitative-performance settings.
4. Kitchen hood airflow balancing.
5. Vibration measuring.
6. Sound level measuring.
7. Indoor-air quality measuring.
8. Verifying that automatic control devices are functioning properly.
9. 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 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 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.

1.7 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 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

A. Balance the primary system crossover flow first, then balance the secondary system.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

3.12 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.13 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser-water flow rate recirculating through the cooling tower.
6. Measure cooling tower pump discharge pressure.
7. Adjust water level and feed rate of makeup-water system.

3.14 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.

3.15 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. Electric-Heating Coils: Measure the following data for each coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. 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.

3.16 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.

3.17 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.

1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches (300 mm) between points and between any point and the perimeter. Calculate the average of

the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.

3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.

1. Check duct slopes as required.
2. Verify that duct access is installed as required.
3. Verify that point of termination is as required.
4. Verify that duct air velocity is within the range required.
5. Verify that duct is within a fire-rated enclosure.

D. Report deficiencies.

3.18 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.

3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.19 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.

3.20 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.

3.21 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.

3.22 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. Air-Handling 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. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.

c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btuh.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btuh.
i. High-fire fuel input in Btuh.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btuh.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btuh.

I. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btuh.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btuh.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.

e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

J. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. 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.

K. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

L. 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.

M. 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. Water-Cooled Condenser Test Data (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.

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.

N. 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.

O. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:

1. Unit Data:

a. Unit identification.
b. Make and type.
c. Model and serial numbers.
d. Nominal cooling capacity in tons.
e. Refrigerant type and weight in lb.
f. Water-treatment chemical feeder and chemical.
g. Number and type of fans.
h. Fan motor make, frame size, rpm, and horsepower.
i. Fan motor voltage at each connection.
j. Sheave make, size in inches, and bore.
k. Sheave dimensions, center-to-center, and amount of adjustments in inches.
l. Number of belts, make, and size.
m. Pump make and model number.
n. Pump manufacturer's serial number.
o. Pump motor make and frame size.
p. Pump motor horsepower and rpm.

2. Pump Test Data (Indicated and Actual Values):

a. Voltage at each connection.
b. Amperage for each phase.

c. Water flow rate in gpm.

3. Water Test Data (Indicated and Actual Values):

a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Water temperature differential in deg F.
d. Entering-water pressure in feet of head or psig.
e. Leaving-water pressure in feet of head or psig.
f. Water pressure differential in feet of head or psig.
g. Water flow rate in gpm.
h. Bleed water flow rate in gpm.

4. Air Data (Indicated and Actual Values):

a. Duct airflow rate in cfm.
b. Inlet-duct static pressure in inches wg.
c. Outlet-duct static pressure in inches wg.
d. Average entering-air, wet-bulb temperature in deg F.
e. Average leaving-air, wet-bulb temperature in deg F.
f. Ambient wet-bulb temperature in deg F.

P. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Ratings.

Q. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.

p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

R. Boiler Test Reports:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Fuel type and input in Btuh.
g. Number of passes.
h. Ignition type.
i. Burner-control types.
j. Voltage at each connection.
k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):

a. Operating pressure in psig.
b. Operating temperature in deg F.
c. Entering-water temperature in deg F.
d. Leaving-water temperature in deg F.
e. Number of safety valves and sizes in NPS.
f. Safety valve settings in psig.
g. High-limit setting in psig.
h. Operating-control setting.
i. High-fire set point.
j. Low-fire set point.
k. Voltage at each connection.
l. Amperage for each phase.
m. Draft fan voltage at each connection.
n. Draft fan amperage for each phase.
o. Manifold pressure in psig.

S. Air-to-Air Heat-Recovery Unit Reports:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.

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. If fans are an integral part of the unit, include the following for each fan:

a. Make and type.
b. Arrangement and size.
c. Sheave make, size in inches, and bore.
d. Sheave dimensions, center-to-center, and amount of adjustments in inches.

4. Test Data (Indicated and Actual Values):

a. Total exhaust airflow rate in cfm.
b. Purge exhaust airflow rate in cfm.
c. Outside airflow rate in cfm.
d. Total exhaust fan static pressure in inches wg.
e. Total outside-air fan static pressure in inches wg.
f. Pressure drop on each side of recovery wheel in inches wg.
g. Exhaust air temperature entering in deg F.
h. Exhaust air temperature leaving in deg F.
i. Outside-air temperature entering in deg F.
j. Outside-air temperature leaving in deg F.
k. Calculate sensible and total heat capacity of each airstream in MBh.

T. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.23 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.

3.24 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

SECTION 23 07 00

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. Cellular glass.
   b. Flexible elastomeric.
   c. Mineral fiber.
   d. Phenolic.
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.

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. Qualification Data: For qualified Installer.

C. 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.

D. Field quality-control reports.

E. 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. 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.

G. 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.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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.

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. Cellular-Glass and Phenolic 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).

C. Flexible Elastomeric 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).

D. 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).

E. 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).

F. 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 and Phenolic 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 covers.

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"irestopping 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 ends 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, 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 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.

3.8 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.

3.9 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.

3.10 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.

3.11 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-presized 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.

3.12 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.

3.13 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.

3.14 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply, return, and outdoor air.

2. Indoor, exposed outdoor air.

3. Indoor, concealed and exposed kitchen hood make-up air.

4. Outdoor, concealed supply and return.

5. 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, including Type I & II Kitchen Exhaust and Dishwasher Exhaust
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.

3.15 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Supply-air Ducts, Concealed (installed above ceilings):
   1. Mineral-Fiber Blanket: 2 inches thick and installed R-6.0.
   2. Where indicated, wrap supply ductwork with a mass loaded vinyl noise barrier.

B. Return Air Ducts, Concealed (installed above ceilings):
   1. Mineral-Fiber Blanket: 2 inches thick and installed R-6.0.

C. Exposed Supply Ductwork in Air Conditioned, Occupied Spaces:
   1. Double wall spiral ductwork, see section 23 31 13 Metal Ducts for liner requirements.

D. Exposed Return Ductwork in Air Conditioned, Occupied Spaces, and Exhaust Air Ductwork:
   1. None.

E. 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-6.0.

F. Outside-Air Ducts:
   1. Mineral-Fiber Blanket: 2 inches thick and installed R-6.0.

G. Type-I Commercial Kitchen Hood Exhaust Ducts:
   1. Fire Rated Insulation System as identified in this specification section.

H. Type-II Commercial Kitchen Hood and Dishwasher Exhaust Ducts:
   1. None.

I. Kitchen Hood Make-Up Air Ducts:
   1. Mineral-Fiber Blanket: 2 inches thick and installed R-6.0.

3.16 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.

C. Heating-hot-water expansion/compression tank insulation shall be one of the following:
   1. Cellular Glass: 1-1/2 inches thick.

2. Flexible Elastomeric: 1 inch thick.
3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

D. Heating-hot-water air-separator insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches thick.
2. Flexible Elastomeric: 1 inch thick.
3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

E. Condenser-water air-separator insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches thick.
2. Flexible Elastomeric: 1 inch thick.
3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
4. Polyisocyanurate: 1 inch thick.

3.17 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.

3.18 INDOOR PIPING INSULATION SCHEDULE

A. Condensate, Cold Water Make-up 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.

B. Condenser-Water Supply and Return:

1. Insulation shall be one of the following:

   a. Cellular Glass: 2 inches thick.
   b. Mineral-Fiber, Preformed Pipe, Type I or Pipe Insulation Wicking System: 1-1/2 inches thick.
   c. Phenolic: 1 inch thick.

C. Heating-Hot-Water Supply and Return:

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

   a. Cellular Glass: 2 inches thick.
   b. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   c. Phenolic: 1-1/2 inch thick.

2. NPS 2” and Larger: Insulation shall be the following:

a. Cellular Glass: 2 inches thick.

b. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

c. Phenolic: 2 inch thick.

D. Refrigerant Suction and Hot-Gas Piping:

1. Insulation shall be installed per the manufacturer’s recommendations.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Condenser-Water Supply and Return:

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

a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Phenolic: 1 inch thick.

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches thick.

C. See section 23 21 14 Preinsulated Below Grade Piping.

3.21 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.

3.22 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. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

2. Aluminum, Smooth: 0.016 inch thick.

3.23 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

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

END OF SECTION

SECTION 23 09 00

DIRECT DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 15 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 15 seconds.
3. Object Command: Reaction time of less than ten seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within ten seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as one minute, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per 10 seconds.
8. Reporting Accuracy and Stability of Control: Maintain measured variables within tolerances as follows:
    a. Space Temperature: Plus or minus 1.5 deg F.

b. Ducted Air Temperature: Plus or minus 2 deg F.

c. Outside Air Temperature: Plus or minus 2 deg F.

d. Dew Point Temperature: Plus or minus 3 deg F.

e. Temperature Differential: Plus or minus 0.25 deg F.

f. Relative Humidity: Plus or minus 5 percent.

g. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.

h. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

i. Airflow (Terminal): Plus or minus 10 percent of full scale.

j. Air Pressure (Space): Plus or minus 0.01-inch wg.

k. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

l. Carbon Dioxide: Plus or minus 50 ppm.

1.5 SEQUENCE OF OPERATION – See Plans for points list and sequence of operation.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submittals shall demonstrate compliance with technical requirements by reference to each subsection of the specification. Where a specific item does not comply with the specification requirements, the deviation shall be presented to the Owner and A/E a minimum of 14 working days prior to bid, along with information as to how the intent of the specification requirement is to be satisfied, for approval. It is the Contractor’s responsibility to demonstrate compliance.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.
8. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.

E. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals on pdf file on local C:drive.
2. Program Software Backup: On a magnetic media or compact disc or on local computer C:drive, complete with data files.
3. Device address list.
4. Software license required by and installed for DDC workstations and control systems.

F. Qualification Data: The DDC system as specified herein shall be provided in its entirety by the controls contractor. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing and installing automatic temperature control systems shall not be acceptable. Bids and work must be performed by the manufacturer’s local factory office.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Help function when using building automation software.
4. Final shop drawings as-builts and product data sheets and sequence of operation.

5. Verification records and list of set points.
6. Three copies of O/M shall be supplied and utilized in operator's training.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's who is trained and approved for installation of system components required for this Project. At a minimum, three fulltime factory trained and certified servicemen located with twenty five miles of building services shall be employed by controls subcontractor.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. The system shall have UL 916, UL873 or UL 864 listing applicable to the application and installation.

C. Comply with ASHRAE 135 for DDC system components.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, CO2 sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate with Division 23 section for "Boilers". It is the intent that the Boiler manufacturer is to provide communications gateway to interface with building automation system. Controls subcontractor is to review the boiler specification and bring to the A/E attention if the boiler specification is not properly coordinated.

D. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve 120Vac for building automation system. BAS contractor shall provide all 120Vac circuits required for building automation use from any nearest electrical panel available spare circuit. Mark locations on as-built drawings.

E. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

F. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

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 CONTROL SYSTEM

A. Manufacturers:

1. Reliable Controls Corporation, Mach-System by Building Automation Services
2. Automated Logic Controls
3. Johnson Controls Inc.

B. Qualification Data: The DDC system as specified herein shall be provided in its entirety by the controls contractor. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing and installing automatic temperature control systems shall not be acceptable. Bids and work must be performed by the manufacturer’s local factory office.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems. Common industry protocols shall be BacNet over IP, LonTalk for all systems including primary and secondary networks. Ethernet connections to interface with the LAN or WAN.

D. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 DDC EQUIPMENT

1. Custom Application Software:
   a. English language oriented.
   b. Full-screen character editor/programming environment.
   c. Allow development of independently executing program modules with debugging/simulation capability.
   d. Support conditional statements.
   e. Support floating-point arithmetic with mathematic functions.
   f. Contains predefined time variables.

B. Building Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

d. Software applications, scheduling, and alarm processing.

e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.

b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

d. Remote communications.

e. Maintenance management.

f. Units of Measure: Inch-pound and SI (metric).

4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

5. LonWorks or BACnet Compliance: Control units shall use LonTalk or BACnet protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. Programmable Direct Digital Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

5. LonWorks or BACnet Compliance: Control units shall use LonTalk or BACnet protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation..
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity..

2.4 WEB BASE OPERATOR INTERFACE

A. System shall include a web-based operator (WEB-OPS) interface to allow user functions to be accomplished from any network connected PC that includes a web browser.

B. Operators shall be able to utilize a browser such as Microsoft Internet Explorer with the appropriate plug-in software.

C. All communications between the web browser and web page server shall be encrypted using 128 bit SSL encryption.

D. The web page server shall be able to be located on the owners Intranet or on the Internet.

E. The system shall have adequate capacity to store and serve up to 450 user defined graphics that each include up to 30 points per graphic.

F. Any unlimited number of users shall be able to access system web pages. Up to 30 users shall be able to use the system simultaneously.

G. Operators shall be required to enter a valid user name and password to access the system. The view of the system provided for the user will be customized based on user identity.

H. Operator security. Each operator shall be able to be assigned a unique user name and password. Users shall be assigned to view, view and edit or administrative capability.

I. The web-based operator interface shall display the same graphics that have been created for any associated Windows-based Operators Workstation. Graphics shall be able to contain both static information such as floor plans and equipment schematics, as well as dynamic information including space temperatures, setpoints, and equipment status information.

J. All dynamic values shall be refreshed with live data upon initial graphic presentation and automatically refreshed every 10 seconds thereafter. The refresh of dynamic data shall not require a refresh of the static information on the graphic.

K. Operators with proper security shall be able to override setpoints and equipment operation.

L. System schedules shall be easily selected for display. Operators with valid security shall be allowed to make changes to schedules including modifications to start and stop times and creating exception days. These changes shall be made graphically within the web browser.

M. A log of system alarms and events shall be able to be viewed from the web browser. Operators with proper security shall be able to acknowledge alarms.

N. System trends shall be able to be selected and viewed. Trends shall be shown graphically with the proper axis scaling automatically selected. Multiple trends shall be able to be viewed at one time.

2.5 UNITARY APPLICATION SPECIFIC AND PROGRAMMABLE CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.
3. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
4. Enclosure: Dustproof rated for operation at 32 to 120 deg F.
5. Enclosure: Waterproof rated for operation at 40 to 120 deg F.

2.6 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 and Terminal Unit Thermostats and other Thermistor Temperature Sensors (type II) and Transmitters:

1. Manufacturers:
   a. Kele (Room sensor ST-S24-EW-XA).
   b. MAMAC Systems, Inc (Room sensor TE-205-EX-X-2).
   c. Trane (Room sensor BAYSEN074A).
2. Accuracy: Plus or minus 1 deg F at calibration point.
3. Wire: as recommended by building automation system provider.
4. Insertion Elements in Ducts: Single point, length as required by application.
5. Averaging Elements in Ducts: 12 inches.
6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor: Kele ST-S24-EW-XA. Sensor with lever setpoint adjust, on/override to. Trane BAYSEN074A.
8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:

1. Manufacturers:
   a. Kele.
   b. MAMAC Systems, Inc.
   c. Basys.

d. Veris.

e. Trane.

2. Accuracy: Plus or minus 1 deg F at calibration point.

3. Wire: as recommended by building automation system provider.

4. Insertion Elements in Ducts: Single point, length as required by application.

5. Averaging Elements in Ducts: 12 inches.

6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.

7. 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.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

D. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:

a. ACI model A/RH3-D.

b. Vaisala HMD50U.

c. Trane 3% RH series type.

2. Accuracy: 3 percent full range with linear output.

3. Room Sensor Range: 20 to 80 percent relative humidity.

4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 0 to 120 degrees.

7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Manufacturers:

a. Kele.

b. General Eastern Instruments.

c. MAMAC Systems, Inc.

d. TCS/Basys Controls.

e. Vaisala.

f. Trane.

2. 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.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

4. 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.

5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.7 STATUS SENSORS

1. Manufacturers:

a. Trane.

b. Veris.

c. Kele.

B. 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.

C. 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.

D. 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.

E. 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.

F. 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.

1. Manufacturers:

a. JCI.

b. I.T.M. Instruments Inc.

c. Trane.

2.8 CO2 and CO sensors

A. Manufacturers:

1. Telaire.

2. Veris.

3. Kele.

4. Vaisala.
5. Trane.

B. 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.

2.9 AIR/WATER FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station. Outside air flow station to be provided by RTU equipment manufacturer.

1. Manufacturers:
    a. Air Monitor Corporation.
    b. Ebtron Gold Series.
    c. Trane Traq.
2. Casing: Galvanized-steel frame.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch (20-mm) parallel cell, 3 inches (75 mm) deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.
5. Factory mounted Traq damper is acceptable.
6. Ebtron thermal dispersment technology type is acceptable.
7. For water flow Onicon F1210 dual turbine flow meter.

2.10 THERMOSTATS

A. Manufacturers:

1. Kele.
2. Trane.
3. JCI.

B. 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.

C. 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.

D. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (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.

E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in 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.

F. 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.

G. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

H. 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.

I. 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.

2.11 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. Belimo, Trane or approved equal. 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. Manufacturers:
   a. Belimo Aircontrols (USA), Inc.
   b. Trane.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. 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.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24 V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
10. Tri-state: Floating signal.
11. Temperature Rating: 40 to 104 deg F (5 to 40 deg C).
12. Run Time: Sized as required for application.

2.12 DAMPERS

A. Manufacturers:

1. Ruskin.
2. Trane.
3. JCI.
4. United Enertech Corp.

B. 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.

2.13 CONTROL CABLE

A. HVAC control system 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices as shown on drawings above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Mechanical contractor shall install automatic dampers according to Division 23 Section "Air Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

G. Mechanical contractor shall install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

H. Mechanical contractor shall install steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam and Condensate Heating Piping."

I. Mechanical contractor shall install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."

J. Mechanical contractor shall install duct volume-control dampers according to Division 23 Sections specifying air ducts.

K. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable for building automation system:

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed. In mechanical rooms, install wiring in conduit.
2. In concealed accessible area, install cable using plenum rated cable or in cable tray.
3. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
6. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing.

B. Perform the following field tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are in correct direction..
9. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that main building unit controller(s) are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Verify reading to within accuracy tolerance or use factory calibrated device.
2. Control System Inputs and Outputs:
   a. Check analog inputs to verify reading is within accuracy tolerance.
   b. Stoke analog output from 0 to 100% span.

c. Check digital inputs using jumper wire.

d. Energize binary output to verify operation.

B. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

B. Demonstrate that all controls are installed, adjusted and can perform all functions required. When coordinated with the Energy Manager with an advance two-week notice, this demonstration may be performed in conjunction with instructions to the Owner’s operations personnel.

C. Final Operational Test: Performance test period is not less than 720 consecutive hours until performance standard is met. Operation reliability level of at least 95%. Whenever downtime occurs, correct defects before resuming test. Failure, due to an individual sensor or controller shall not count as system downtime provided that the system records the fault or that the reliability level for all sensors and controllers together is at least 99 percent of the test period.

3.7 TRAINING

A. Refer to 230500

3.8 WARRANTY SERVICE

A. Provide all labor, material and equipment necessary to maintain beneficial performance of the entire control system for a period of one (1) year after acceptance by an authorized representative of the Owner. The controls subcontractor at no charge to the Owner shall promptly correct any defects in workmanship or material during the warranty period. All work shall be accomplished during normal working hours M-F if possible. Critical component failure shall be repaired immediately whether labor involves overtime, weekend, or holidays. Precaution shall be taken to minimize disruption of facility operations.

B. Owner’s involvement in modifications to hardware and/or software or the addition of panels and points shall not void warranty.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
1. Hot-water heating piping.
2. Chilled-water piping.
3. Makeup-water piping.
4. Condensate-drain piping.
5. Blowdown-drain piping.
6. Air-vent piping.
7. Safety-valve-inlet and -outlet piping.

B. Related Sections include the following:
1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 200 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.4 ACCEPTABLE MANUFACTURERS

A. All piping shall be manufactured in the USA.

1.5 SUBMITTALS

A. Product Data: For each type of the following:
1. Plastic pipe and fittings with solvent cement.
2. Pressure-seal fittings.
3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
4. Air control devices.
5. Chemical treatment.
6. Hydronic specialties.

B. Welding certificates.

C. Qualification Data: For Installer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.6 QUALITY ASSURANCE

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

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.7 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

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

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

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

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

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

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

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

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

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

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

G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
   1. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:
   1. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:

1. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:
1. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples:
1. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.5 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. 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. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Griswold Controls.
   e. Taco.

4. Body: Bronze, ball or plug type with calibrated orifice or venturi.
5. Ball: Brass or stainless steel.
6. Plug: Resin.
7. Seat: PTFE.
8. End Connections: Threaded or socket.
9. Pressure Gage Connections: Integral seals for portable differential pressure meter.
10. Handle Style: Lever, with memory stop to retain set position.
11. CWP Rating: Minimum 125 psig.
12. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. 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. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump; a division of ITT Industries.
c. Flow Design Inc.
d. Griswold Controls.
e. Taco.

4. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
5. Ball: Brass or stainless steel.
6. Stem Seals: EPDM O-rings.
7. Disc: Glass and carbon-filled PTFE.
8. Seat: PTFE.
9. End Connections: Flanged or grooved.
10. Pressure Gage Connections: Integral seals for portable differential pressure meter.
11. Handle Style: Lever, with memory stop to retain set position.
12. CWP Rating: Minimum 125 psig.
13. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. 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. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump; a division of ITT Industries.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

4. Body: Bronze or brass.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: Brass.
7. Stem Seals: EPDM O-rings.
8. Diaphragm: EPT.
9. Low inlet-pressure check valve.
10. Inlet Strainer: stainless steel, removable without system shutdown.
11. Valve Seat and Stem: Noncorrosive.
12. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump; a division of ITT Industries.

d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. 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. Flow Design Inc.
b. Griswold Controls.
c. PRO-Hydronics

4. Body: Brass or ferrous metal.
5. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
6. Combination Assemblies: Include bonze or brass-alloy ball valve.
7. Identification Tag: Marked with zone identification, valve number, and flow rate.
8. Size: Same as pipe in which installed.
9. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
10. Minimum CWP Rating: 175 psig.
11. Maximum Operating Temperature: 250 deg F.
12. Extra Materials: Provide additional flow cartridges as required for rebalancing of terminal unit water flows. Provide either:
a. Provide replacement flow cartridges for one (1) year, free of charge.
b. Additional flow cartridges equal to three (3) each of the following for each cartridge size installed: 1 GPM, 1.5 GPM, 2 GPM, 2.5 GPM, 3 GPM, 5 GPM.

2.6 AIR CONTROL DEVICES

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.

4. Taco.

C. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

D. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

E. Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

F. Bladder-Type Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

G. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

H. Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 deg F.

2.7 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
   1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.8 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 125 psig.

B. Basket Strainers:
   1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 125 psig.

C. T-Pattern Strainers:
   1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
   2. End Connections: Grooved ends.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
   4. CWP Rating: 750 psig.

D. Stainless-Steel Bellow, Flexible Connectors:
   1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
   2. End Connections: Threaded or flanged to match equipment connected.
   3. Performance: Capable of 3/4-inch misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

E. Spherical, Rubber, Flexible Connectors:
   1. Body: Fiber-reinforced rubber body.
   2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   3. Performance: Capable of misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

F. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Schedule 40 steel pipe; Class 150, Victaulic Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa) as provided standard Victaulic.
   2. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   3. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   1. Schedule 40 steel pipe; Victaulic Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa) as provided standard Victaulic.
   2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. Do not install PVC piping in return air plenums.

G. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

H. Air-Vent Piping:
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
   2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

I. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

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

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

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

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

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

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

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

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Victaulic Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa) as provided standard Victaulic.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

E. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum 100 ppm.
5. Corrosion Inhibitor:
    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.
6. Soluble Copper: Maximum 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
8. Total Suspended Solids: Maximum 10 ppm.
9. Ammonia: Maximum 20 ppm.
10. Free Caustic Alkalinity: Maximum 20 ppm.
11. Microbiological Limits:
    a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
    c. Nitrate Reducers: 100 organisms/ml.
    d. Sulfate Reducers: Maximum 0 organisms/ml.
    e. Iron Bacteria: Maximum 0 organisms/ml

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 24 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 23 31 13
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. Duct liner.
6. Sealants and gaskets.
7. 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. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

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. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 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.

E. 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.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. CertainTeed Corporation; Insulation Group.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Owens Corning.
3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and

erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
    a. 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).

B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 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.

2.7 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 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. 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 Than2-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 Classes2-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.

3.5 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 intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 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.

3.8 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.

3.9 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. All concealed low pressure supply mains from built up Air Handing Units.
   c. 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.

3.10 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.

3.11 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel unless noted otherwise.

B. Supply Ducts:
1. Ducts Connected to Indoor Units and Packaged Heat Pumps:
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 Commercial Kitchen Hoods: Comply with NFPA 96.

a. Exposed to View: Type 304, stainless-steel sheet, No. 4 finish.
b. Concealed: Carbon-steel sheet.
c. Welded seams and joints.
d. Pressure Class: Positive or negative 3-inch wg.
e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
f. SMACNA Leakage Class: 3.

3. Ducts Connected to Dishwasher Hoods:
   a. Type 304, stainless-steel sheet.
   b. Exposed to View: No. 4 finish.
   c. Concealed: No. 2D finish.
   d. Welded seams and flanged joints with watertight EPDM gaskets.
   e. Pressure Class: Positive or negative 2-inch wg.
   f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
   g. SMACNA Leakage Class: 3.
4. 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.

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

SECTION 23 33 00

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. Combination fire and smoke dampers.
7. Flange connectors.
8. Duct silencers.
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. METALAIRE, 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. Air Balance Inc.; a division of Mestek, Inc.

2. Greenheck Fan Corporation.

3. Nailor Industries Inc.

4. Pottorff; a division of PCI Industries, Inc.

5. NCA Manufacturing.

6. Ruskin Company.

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. Air Balance Inc.; a division of Mestek, Inc.

2. Greenheck Fan Corporation.
3. Nailor Industries Inc.
4. NCA Manufacturing.
5. Ruskin Company.

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 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Industrial Noise Control, Inc.
   2. McGill AirFlow LLC.
   3. Ruskin Company.
   4. Vibro-Acoustics.
   5. Price.

B. General Requirements:
   1. Factory fabricated.
   2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

C. Shape:
   1. Rectangular straight with splitters or baffles.
   2. Round straight with center bodies or pods.
   3. Rectangular elbow with splitters or baffles.
   4. Round elbow with center bodies or pods.
   5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G60, galvanized sheet steel, 0.034 inch thick.

E. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations.

F. Special Construction:
   1. Suitable for outdoor use.
   2. High transmission loss to achieve STC 45.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:
   1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
   2. Dissipative type with fill material.
      a. Fill Material: Moisture-proof nonfibrous material.
      b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
   3. Lining: Mylar bag.

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Lock form and seal or continuously weld joints.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Source Quality Control: Test according to ASTM E 477.

1. Testing in accordance with ASTM E-477.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

K. Capacities and Characteristics: As indicated on the drawings.

2.9 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.

2.10 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.

2.11 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.

2.12 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. 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.

2.13 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.

2.14 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.

2.15 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 inch to three inch 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 the FE-1500 as manufactured by Paragon Controls Incorporated (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% F.S./□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% F.S. (Terminal Point) / +0.35% F.S. (BFSL)

8. The airflow indicating transducers shall be the FIT-1001D as manufactured by Paragon Controls Incorporated (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. Where noted on plans: 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

SECTION 23 34 23

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. Centrifugal roof ventilators.
2. Ceiling-mounting ventilators.
3. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck
2. Loren Cook Company
3. Penn Ventilation
4. Twin City Fans

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.

1.5 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 CENTRIFUGAL ROOF VENTILATORS

A. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector for UL 762 kitchen hood exhaust fans.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

E. Accessories: (See drawings for required accessories).

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops. Backdraft dampers on all roof mounted supply fans shall be motorized.

F. Roof Curbs: Galvanized steel; welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 8 inches (unless noted otherwise).
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.
5. Burglar Bars: 1/2-inch- thick steel bars welded in place to form 6-inch squares (where indicated on the drawings).
6. Vented Curb: Unlined with louvered vents in vertical sides (where indicated on the drawings).

G. Capacities and Characteristics: As indicated on the drawings.

2.2 CEILING-MOUNTING VENTILATORS

A. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories: (See drawings for required accessories).

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

G. Capacities and Characteristics: As indicated on the drawings.

2.3 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.

2.4 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

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

SECTION 23 37 13

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. Louver face diffusers.
3. Adjustable Bar Register
4. Fixed face registers.

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

1. Carnes
2. METALAIRE, Inc.
3. Nailor industries
4. Price
5. Titus
6. Tuttle & Bailey
7. Krueger

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 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. 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 REGISTERS AND GRILLES

A. Adjustable Bar Register:

1. Material: Steel or Aluminum as indicated on the drawings.
2. Finish: Baked enamel, white unless noted otherwise.
3. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.

4. Core Construction: Integral.
5. Rear-Blade Arrangement: Vertical spaced 3/4 inch apart.
6. Frame: 1-1/4 inches wide.
7. Mounting: Concealed.
8. Damper Type: Adjustable opposed blade.
9. Accessories:
   a. Rear-blade gang operator.
   b. Filter.

B. Fixed Face Register:
1. Material: Steel or Aluminum as indicated on the drawings.
2. Finish: Baked enamel, white unless noted otherwise.
3. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core.
4. Core Construction: Integral.
5. Frame: 1 inch wide.
6. Mounting: Concealed.
7. Damper Type: Adjustable opposed blade.
8. Accessory: Filter.
   a.

2.3 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

SECTION 23 81 27

SPLIT SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting and may be connected to ducts.

1.2 SUBMITTALS

A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Carrier
2. Trane
3. York

2.2 EVAPORATOR-FAN UNIT

A. Concealed Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

1. Insulation: Faced, glass-fiber duct liner.
2. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2007.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Evaporator Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.

D. Fan Motor:
1. Fan: Direct drive, centrifugal.
2. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Enclosure Type: Totally enclosed, fan cooled.
   d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   f. Mount unit-mounted disconnect switches on **exterior** of unit.

E. Filters: 1 inch thick, in fiberboard frames.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER UNIT

A. Casing steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed reciprocating type with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll.
b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
c. Refrigerant: R-410a (unless otherwise indicated on the drawings).
d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Fan: Aluminum-propeller type, directly connected to motor.

E. Motor: Permanently lubricated, with integral thermal-overload protection.

F. Low Ambient Kit: Permits operation down to 45 deg F.

G. Mounting Base: Polyethylene.

H. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2007, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

1. Minimum Insulation Thickness: 1/2 inch thick.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

B. Install ground-mounted, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

C. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

D. 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.

E. 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."

3.2 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 shutoff-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.

3.3 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 81 26

SECTION 23 82 19

FAN COIL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Blower Coils

1. Belt-Driven Air Handling Units - 0.8 square feet to 6.25 square feet of coil face area

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 230900 – Direct Digital Control System.

B. Section 260523 – Control Voltage Electrical Power Cables

1.3 RELATED SECTIONS

A. Section 230900 – Direct Digital Control System.

B. Section 260519 – Low Voltage Electrical Power Conductors and Cables.

1.4 REFERENCES

A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

B. UL 181 - Factory-Made Air Ducts and Connectors.

C. UL 1995 - Heating and Cooling Equipment.

D. NMFC item 180: Package Performance Testing in accordance with National Motor Freight Classification.

E. ARI 260-2001 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment.

1.5 QUALITY ASSURANCE

A. ISO 9001 Certification.

B. Unit designed and tested in compliance with ARI 430 air delivery ratings per ARI 430-1999.

C. Unit designed and tested in compliance with ARI 260-2001.

1.6 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 service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit data on electrical requirements. Include safety and start-up instructions.

1.7 REGULATORY REQUIREMENTS

A. Unit shall be manufactured to conform to UL 1995 Standard and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to unit.

B. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense provide for a field inspection by a UL/CUL representative to verify conformance. If necessary, contractor shall perform modifications to the unit(s) to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the Owner.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags on each section to indicate location and orientation in direction of airflow. Each section shall have lifting points to allow for field rigging and final placement of section.

C. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Deliver units to site with fan motors, sheaves, and belts completely assembled and mounted in units. If these components are not completely assembled, contractor shall be responsible for all expenses associated with installation, testing, and vibration balancing of fan(s).

1.9 START-UP AND OPERATING REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.10 WARRANTY

A. The equipment manufacturer shall provide, at no additional cost, a STANDARD PARTS WARRANTY that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Approved manufacturers shall be:
1. Trane
2. Carrier
3. York
4. Pre-approved alternates will be considered. Pre-approval must be obtained from consulting engineer prior to bid day. Alternates must comply with all performance and features as called for in this specification. Job awarded on basis of specified machine. Alternate will be evaluated and considered after job is awarded.

B. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 GENERAL UNIT DESCRIPTION

A. Manufacturer shall provide unit arranged for draw-through application. Unit layout and configuration shall be as defined in project plans and schedule. Blow-through is only acceptable when consideration is given to capturing downstream moisture carryover. Considerations include downstream moisture eliminators and/or extended blank modules with condensate drain pans.

2.3 UNIT CASING MOTOR CHARACTERISTICS

A. The entire air handler shall be constructed of galvanized steel. The removal of side panels shall not affect the structural integrity of the unit once the unit is installed. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

B. Access panels shall be on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.

C. Units shall ship as one or two modules completely factory-assembled including all coils, fans, motors, drives, dampers and filters.

D. Access Panels: Removable access panels shall be provided on both sides of the unit to facilitate service access to drain pans, motors, drive components and bearings. Panels shall be gasketed. Access panel for filter removal shall be provided on both sides of the unit.

E. Cabinet: Casing shall be manufactured of heavy gauge galvanized steel. All removable panels shall be gasketed to minimize air leakage.

F. Insulation: High density, foil-faced - Interior surface of unit casing shall be acoustically and thermally lined. Insulation shall be installed with adhesive. Insulation shall have a minimum R-Value of 4, shall be UL listed, and shall meet ASTM C 665 Bacteriological Standard requirements. The installation shall comply with NFPA90A and B requirements. All exposed edges shall be sealed to prevent erosion of fibers into the airstream. If edges of fiberglass insulation are exposed, the manufacturer shall be responsible for sealing exposed edges with mastic sealer to prevent erosion into the airstream.

2.4 COILS

A. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

B. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil are as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

C. Construct coil casings of galvanized steel. End supports shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

D. Hydronic Coils

1. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit airflow.
2. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water.
3. Headers shall be constructed of round copper pipe.
4. Tubes shall be 1/2-inch O.D. minimum 0.016-inch-thick copper. Fins shall be aluminum.
5. Coils shall be capable of being rotated in the field for left- or right-hand connection.

2.5 DRAIN PAN

A. Drain Pan(s) shall be constructed of corrosion resistant material. Acceptable materials include polymer or 304 stainless steel. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section.

B. Drain pan manufacturer shall either insulate bottom of drain pan with closed cell foam or provide double wall internally insulated construction to eliminate bottom sweating.

C. Drain pan shall be sloped in two planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation instructions. Units without drain pans sloped in two planes shall coat drain pans with anti-microbial treatment. Drain pan(s) shall have main and auxiliary drain connections with auxiliary outlet higher than the main connection.

D. Coil(s) shall be mounted above the drain pan to facilitate easy and complete inspection, cleaning and removal. Coil(s) may not sit in drain pan.

E. The drain pan shall be capable of being rotated in the field between right- and left-hand connections.

2.6 FANS

A. Provide single-wheel, forward curved centrifugal fans as specified on the schedule. Fan shaft bearings shall be permanently sealed ball bearing with a minimum L50 design life of 200,000 hours.

2.7 MOTORS AND DRIVES

A. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly at no additional cost to the owner.

B. Motors shall be open drip-proof with permanently sealed ball bearings.

C. Motors shall be selected to operate continuously at 130 F (55 C) ambient without tripping on overloads. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

D. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in star-up and services personnel in maintenance:

1. Fan and motor sheave part number.
2. Fan and motor bushing part number.
3. Number of belts and belt part numbers.
4. Fan design RPM and motor HP.
5. Belt tension and deflection.
6. Center distance between shafts.

2.8 FILTERS

A. Provide removable one- or two-inch-thick filters easily removable from either side of the unit. All units shall use standard filter sizes.

2.9 CONTROLS

A. No Controls.

1. Provide unit with fan motor wiring extending to a junction box on the side of the unit.

B. Control Interface.

1. Unit shall be factory run tested and end devices shall be factory wired to terminal strip in a external junction box and tested for wiring continuity.
2. The thermostatic control package shall include the following: 24 VAC transformer, motor contactor(s), disconnect switch (not included with electric heat), and control box enclosure.

C. DDC Controls

1. DDC controller shall be supplied by the BAS contractor to be factory mounted by the fan coil unit manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and opening dimensions are as Indicated on shop drawings.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide units with shut-off valve on supply and lockshield balancing valve on return piping if factory packages are not factory provided.

3.3 CLEANING

A. Clean work.

B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

C. Install new filters.

3.4 FAN COIL UNIT SCHEDULE

See plans for schedules

END OF SECTION

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

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. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 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. So 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."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. 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.

2.2 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:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
   3. 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.
   4. Pressure Plates: Carbon steel. Include two for each sealing element.
   5. 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.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 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.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. 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.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to 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."

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field 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.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Wire Company.
   2. General Cable Technologies Corporation.
   3. Okonite Company (The).
   4. Southwire Company.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Conductor Insulation:
   1. Type USE-2 and Type SE: Comply with UL 854.
   2. Type THHN and Type THWN-2: Comply with UL 83.
   3. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Wire Company.
   2. General Cable Technologies Corporation.
   3. Okonite Company (The).
   4. Southwire Company.

C. Standards:

   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:

   1. Type THHN and Type THWN-2: Comply with UL 83.
   2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.

2.3 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.4 SLEEVES FOR 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 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."

2.5 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products 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 NBR 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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders smaller than No. 1/0 AWG; copper or aluminum for feeders No. 1/0 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway, Type MC Mineral-insulated, Type MI.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. Class 1 Control Circuits: Type THHN-THWN, in raceway.

L. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes Power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 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 rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
   2. For sleeve 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 wall surfaces.

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 cable 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 cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables 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. Size sleeves 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 cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services 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. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
      a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
      b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION

SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLE

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. UTP cabling.
2. 50/125-micrometer, multimode optical fiber cabling.
3. RS-232 cabling.
4. RS-485 cabling.
5. Low-voltage control cabling.
6. Control-circuit conductors.
7. Identification products.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. IDC: Insulation displacement connector.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

E. RCDD: Registered Communications Distribution Designer.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

B. Shop Drawings: For cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
4. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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: 450 or less.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
   2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP and optical fiber cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Support of Open Cabling: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with cable tie slots for fastening cable ties to brackets.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

2.2 BACKBOARDS

A. Description: Plywood, AC Grade, 2 coats fire retardant paint on all sides, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry."

2.3 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.
   1. Belden CDT Inc.; Electronics Division.
   2. CommScope, Inc.
   3. Superior Essex Inc.
   4. SYSTIMAX Solutions; a CommScope, Inc. brand.
   5. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four-pair UTP.
   1. Comply with ICEA S-90-661 for mechanical properties.

2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Verified by NRTL to TIA/EIA-568-B.2, TIA/EIA 568-B.2-1 Category 6.
5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, Limited Purpose: Type CMX complying with UL 1581 VW-1
   b. Communications, General Purpose: Type CM complying with UL 1581(Vertical Tray)
   c. Communications, Riser Rated: Type CMR complying with UL 1666
   d. Communications, Plenum Rated: Type CMP complying with NFPA 262.

2.4 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Voice & Data Division.
   2. Nordex/CDT; a subsidiary of Cable Design Technologies.
   3. Panduit Corp.
   4. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   5. Commscope.

B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.

C. Connecting Blocks: 110 style for Category 6. 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.

2.5 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CommScope, Inc.
   2. Superior Essex Inc.
   3. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Multimode, 50/125-micrometer, 24 fiber, nonconductive, tight buffer, optical fiber cable.
   1. Comply with ICEA S-83-596 for mechanical properties.
   2. Comply with TIA/EIA-568-B.3 for performance specifications.
   3. Comply with TIA/EIA-492AAAA-B for detailed specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 262 for the following types:
      a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
      b. Riser Rated, Nonconductive: Type OFNR complying with UL 1666.
      c. Plenum Rated, Conductive: Type OFCP complying with NFPA 262.
      d. Riser Rated, Conductive: Type OFCR complying with UL 1666.
   5. Conductive cable shall be aluminum-armored type.
   6. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
   7. Minimum Modal Bandwidth: 50 700 MHz-km at 850 nm; 500 MHz-km at 1300 nm

C. Jacket:
   1. Jacket Color: Aqua for 50/125-micrometer cable.
   2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
   3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.6 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Technology Systems Industries, Inc.
   2. Corning Cable Systems.
   3. Dynacom Corporation.
   4. Hubbell Premise Wiring.
   5. Optical Connectivity Solutions Division; Emerson Network Power.
   6. AMP; a Tyco International Ltd. company.

B. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
   1. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
   2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.7 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.
   1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. Polypropylene insulation.
   3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   4. PVC jacket.
   5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
   6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
   1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. Plastic insulation.
   3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   4. Plastic jacket.
   5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
   6. Flame Resistance: Comply with NFPA 262.

2.8 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM.
   1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. PVC insulation.
   3. Unshielded.
   4. PVC jacket.
   5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
   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. Flame Resistance: NFPA 262, Flame Test.

2.9 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.
   1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.

2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

C. Paired Cable: NFPA 70, Type CMG.
1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Plastic jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.10 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway[power-limited cable, concealed in building finishes complying with UL 83.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.11 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
1. Brady Corporation.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.
5. AMP; a Tyco International Ltd. company.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

D. Install manufactured conduit sweeps and long-radius elbows if possible.

E. Pathway Installation in Equipment Rooms:
1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect 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. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. 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.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.2.

2. Install 110-style IDC termination hardware unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:
1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

E. Optical Fiber Cable Installation:
1. Comply with TIA/EIA-568-B.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inchesapart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 72 inches long shall be neatly coiled not less than 12 inches in diameter below each feed point.

H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data 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 and 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 Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:
1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP 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 after cross connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.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.
4. Optical Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.

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. Grounding arrangements and connections for separately derived systems.
   4. Grounding for sensitive electronic equipment.

C. Field quality-control test reports.

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. 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 by10 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. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install barecopper conductor, No. 2/0 AWG minimum, or as indicated on the plans.
   1. Bury at least 24 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. 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.

C. 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.

D. 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.

E. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter 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.

F. 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.

G. 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. 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.

B. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Related Sections include the following:
   1. Division 26 Section "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. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. 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.
   2. Nonmetallic 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. Nonmetallic slotted channel systems. 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/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.
   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.
      f. Unistrut; Tyco International, Ltd.
      g. Wesanco, Inc.
   2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
   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. Fabco Plastics Wholesale Limited.
      d. Seasafe, Inc.
   2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   3. Fitting and Accessory Materials: Same as channels and angles.

4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Not Allowed.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in 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.

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

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. 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.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

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

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. NBR: Acrylonitrile-butadiene rubber.

G. 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. AFC Cable Systems, Inc.
   2. Alflex Inc.
   3. Allied Tube & Conduit; a Tyco International Ltd. Co.
   4. Anamet Electrical, Inc.; Anaconda Metal Hose.
   5. Electri-Flex Co.
   6. Manhattan/CDT/Cole-Flex.
   7. Maverick Tube Corporation.
   8. O-Z Gedney; a unit of General Signal.
   9. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6.

E. PVC-Coated Steel Conduit: PVC-coated IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: ANSI C80.3.

G. FMC: Zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket.

I. 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. Set-screw or crimp shall not be permitted.
   3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

J. 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. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

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 steel 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.
   d. Panduit

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. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

G. 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.

H. 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 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."

2.8 SLEEVE SEALS

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

2.9 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 APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed Conduit: Rigid steel conduit
   2. Concealed Conduit, Aboveground: IMC.
   3. Underground Conduit: RNC, Type EPC- 80-PVC, direct buried.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
   6. 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. MC cable not permitted.
   2. Exposed, Not Subject to Physical Damage: EMT.
   3. Exposed, Not Subject to Severe Physical Damage: EMT.
   4. 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.

5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
7. Damp or Wet Locations: IMC.
8. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
9. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
10. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
11. 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.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.2 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.
3. Change from ENT to rigid steel conduit, or IMC before rising above the floor.

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 semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC 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.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches 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. 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.
6. Provide a bright colored plastic marker strip reading: "Caution - Electrical Conduits" in each underground conduit trench. Install a maximum of 12" below grade or a minimum of 18" above top of duct bank. All underground markings shall have metallic marking tape.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch 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.

3.5 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.

3.6 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.

3.7 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."

3.8 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.9 AS-BUILT COORDINATION

A. Provide dimensioned locations for all underground conduits. A minimum of two dimensions from building reference points shall be provided along with bury depth.

END OF SECTION

SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes aluminum cable trays and accessories.

1.3 SUBMITTALS

A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.
1. Show fabrication and installation details of cable tray, 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. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
   a. Design Calculations: Calculate requirements for selecting seismic restraints.
   b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.

D. Field quality-control reports.

E. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

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

C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc. (Preferred Brand)
2. MONO-SYSTEMS, Inc.
3. Cablofil.

2.2 MATERIALS AND FINISHES

A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.
1. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
2. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 coating; with hardware galvanized according to ASTM B 633.
3. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
4. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2; with chromium-zinc, ASTM F 1136, hardware.
5. PVC coating applied in a fluidized bed or by electrostatic spray; with chromium-zinc, ASTM F 1136 hardware.
6. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment; with cadmium-plated hardware according to ASTM B 766.

B. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with chromium-zinc, ASTM F 1136, splice-plate fasteners, bolts, and screws

C. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304, complying with NEMA VE 1.

D. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.

E. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
1. Center-hanger supports may be used only when specifically indicated.

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. Covers: Louvered type of same materials and finishes as cable tray.

C. Barrier Strips: Same materials and finishes as cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

A. 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."

B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.

B. Remove burrs and sharp edges from cable trays.

C. Fasten cable tray supports to building structure and install seismic restraints.
   1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
   2. Place supports so that spans do not exceed maximum spans on schedules.
   3. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
   4. Support bus assembly to prevent twisting from eccentric loading.
   5. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
   6. Locate and install supports according to NEMA FG 1.

D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.

E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.

F. Make changes in direction and elevation using standard fittings.

G. Make cable tray connections using standard fittings.

H. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

J. Workspace: Install cable trays with enough space to permit access for installing cables.

K. 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.

L. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.2 CABLE INSTALLATION

A. Install cables only when cable tray installation has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. On vertical runs, fasten cables to tray every 18 inches. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

D. In existing construction, remove inactive or dead cables from cable tray.

E. Install covers after installation of cable is completed.

3.3 CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions.

B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70. Refer to NEC 392.

3.4 FIELD QUALITY CONTROL

A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
   1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.

2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
5. 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.
6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

B. Report results in writing.

3.5 PROTECTION

A. Protect installed cable trays.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
1. 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 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.

1.8 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.

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. Manufacturers: Subject to compliance with requirements, provide products 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 EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

C. 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.

D. 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."
   3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
      a. Color: Red dye added to concrete during batching.
      b. Mark each plank with "ELECTRIC" in 2-inch- high, 3/8-inch- deep letters.

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 steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Coordinate remaining subparagraphs and associated subparagraphs below with Drawings.
3. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
4. Cover Legend: Molded lettering, "ELECTRIC." Or "TELEPHONE." As indicated for each service.
5. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
6. 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.
7. 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 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.
8. 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.
9. 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. 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. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carson Industries LLC.
   b. Nordic Fiberglass, Inc.
   c. PenCell Plastics.

2.5 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 Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

D. 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.

E. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

F. 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.

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. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

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.

3.5 INSTALLATION OF HANDHOLES, AND BOXES

A. Precast Concrete Handhole 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.

B. 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.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. 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.

E. 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.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

H. 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.

I. 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 trafficways, 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. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
   3. 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

SECTION 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. 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. The Electrical Contractor shall be responsible for providing restraints to resist the earthquake effects on the electrical system. The requirements for these restraints are found in the ASCE 7.

B. The Electrical Contractor shall refer to the latest edition of the "Seismic Restraint Manual Guidelines for Mechanical System" published by SMACNA for guidelines to determine the correct restraints for sheet metal ducts, piping, and conduit, etc.

C. The Electrical Contractor shall retain the services of a Professional Structural Engineer registered in the State of North Carolina to design seismic restraint elements required for this project. The engineer's computations, bearing his professional seal, shall accompany shop drawings which show Code compliance. Computations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment systems, and assemblies.

D. The professional engineer retained by the Electrical Contractor for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation. This Engineer shall provide in writing verification of compliance with the approved seismic submittal. This verification shall bear the Engineer's professional seal. Job site inspection by other than this

Engineer is not acceptable. This engineer shall also be responsible for any required special inspections and associated documentation related to seismic restraints. Site classification is "D".

E. Seismic-Restraint Loading:
1. Site Class shall be as Defined in the NC State Building Code (Chapter 16) and ASCE 7, as determined by the project Structural Engineer of record.
2. Assigned Seismic Use Group or Building Category shall be as Defined in the NC State Building Code (Chapter 16) and ASCE 7 for the following:
a. Component Importance Factor.
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 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. Manufacturers: Subject to compliance with requirements, provide products 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 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. Perform tests and inspections.

C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through 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.

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

E. Prepare test and inspection reports.

F. The professional engineer retained by the Mechanical Contractor for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation. This Engineer shall provide in writing verification of compliance with the approved seismic submittal. This verification shall bear the Engineer's professional seal. Job site inspection by other than this Engineer is not acceptable. This engineer shall also be responsible for any required special inspections and associated documentation related to seismic restraints.

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

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes 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. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Normal Power = Black; Emergency = Red; UPS = Blue
   3. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

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.

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.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. 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.

C. 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."

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. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

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 or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. 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.

B. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
1. Fire Alarm System: Red.
2. Fire-Suppression Supervisory and Control System: Red and yellow.
3. Combined Fire Alarm and Security System: Red and blue.
4. Security System: Blue and yellow.
5. Mechanical and Electrical Supervisory System: Green and blue.
6. Telecommunication System: Green and yellow.
7. Control Wiring: Green and red.

C. 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.

D. 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.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

F. 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.

G. 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.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning label s. 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.

I. 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.

J. 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:
     a. Indoor Equipment: Engraved, laminated acrylic or melamine label.
     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. Motor-control centers.
     h. Disconnect switches.
     i. Enclosed circuit breakers.
     j. Motor starters.
     k. Push-button stations.
     l. Power transfer equipment.
     m. Contactors.
     n. Remote-controlled switches, dimmer modules, and control devices.
     o. Battery inverter units.
     p. Battery racks.
     q. Power-generating units.
     r. Voice and data cable terminal equipment.
     s. Master clock and program equipment.

t. Intercommunication and call system master and staff stations.
u. Television/audio components, racks, and controls.
v. Fire-alarm control panel and annunciators.
w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
x. Monitoring and control equipment.
y. Uninterruptible power supply equipment.
z. 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.
3. Colors for 480/277-V Circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
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

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: The following specifications detail the minimum performance and related criteria for the Lighting Control System. Provide, connect, and furnish all necessary equipment for proper installation and service of the Lighting Control System indicated on the drawings and specified herein.

1.2 DESCRIPTION OF WORK

A. The extent of lighting control system work is indicated by the drawings and the requirements of this section. The Lighting Control System as defined under this section includes all lighting control equipment, user interface devices, occupant and daylight sensors, and ancillary programming equipment. Types of equipment and wiring specified in this section include the following:

1. Programmable Light Energy Managers with time clock
2. Multi-level drivers or Full dimmable
3. Occupancy and Daylight Sensor Connectors
4. Wall controllers
5. Building Automation Interface

B. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways, electrical boxes, wire, lighting fixtures, and fittings required for installation of the lighting control system, which are not part of this section.

C. It is the responsibility of the lighting supplier to meet the intent of these specifications. Where a specific piece of equipment cannot meet the requirements from the base design system, it is the manufacturer's responsibility to supplement the device in order to meet the intent with additional relays, graphical interface, switch controllers, etc.

1.3 SUBMITTALS

A. Alternate and substituted equipment submittals shall provide a written line-by-line review of the specification.

B. Submit the following according to the Conditions of the Contract, Division 1 and Division 16 Specification Sections.

1. Product data for each of the products specified. Include data on features, components, ratings, and performance. Include dimensioned drawings with isometric projections of components and enclosures.
2. Sample of the equipment, devices, and device plates (white) for color selection and evaluation of technical features, as required by Engineer.
3. Wiring diagrams detailing internal and interconnecting wiring for power signal, and control that distinguish between field-installed and factory-installed wiring.
4. Equipment Riser (one-line) Diagram with wire type details.
5. Complete details on BACnet connection to Building Automation System, including complete Protocol Implementation Conformance Statement (PICS).

1.4 APPROVALS

A. Prior approval is required for alternate proposals in accordance with this project's specifications general requirements.

B. Complete Catalog data, specifications, and technical information on alternate equipment must be furnished to the Engineer, Architect, and Owner on the bid date.

C. System must utilize a passive detection technology. Ultrasonic sensor systems will not be allowed that interfere with the "Mimio" technology school system will be using. All control systems submitted shall have documentation stating non-interference.

1.5 QUALITY ASSURANCE

A. Manufacturer experience: manufacturer of Lighting Control System shall have a minimum of 10 years of continuous experience in manufacturing lighting control products and luminaires.

B. To insure a single source of responsibility, all switching, dimming, and related lighting control equipment described herein shall be supplied by the lighting manufacturer.

C. Manufacturer shall have a nationwide network of factory trained and authorized service representatives capable of providing initial system commissioning, ongoing service contracts and on-site post-installation service support.

D. Approvals – all primary equipment and related accessories shall be UL or CSA marked as appropriate.

E. If requested, the contractor/manufacturer shall supply to the owner a written certification of compatibility to ensure that all components of the Lighting Control System, as defined in Section 1.3 and the remainder of this document, are fully compatible with each other for proper system functionality. This includes control electronics, sensors, drivers, and lamps.

1.6 WARRANTY

A. The manufacturer shall provide at minimum, a full one-year warranty on all equipment supplied. A three-year warranty shall be furnished on all equipment supplied when system is installed with modular wiring. A five year warranty shall be furnished on all compatible drivers.

1.7 COMMISSIONING (Required)

A. System Checkout, programming, and training – A factory certified technician shall functionally test the system, program all settings and schedules per owner's specification, and verify performance after contractor installation. It shall be the contractor's responsibility to coordinate with the owner and supply the necessary "as-installed" information and desired schedules to the manufacturer in a timely manner. The factory certified technician shall conduct a training session for the building operations personnel on the set-up, programming, operation and maintenance of the lighting control system. In addition to the commissioning and training, provide up to three visits to trouble shoot and set the systems. Full day visits, travel and expenses shall be included. Three additional full day visits shall be provided for post final/CO testing, refining and commissioning.

PART 2 - EQUIPMENT

2.0 SYSTEM DESCRIPTION

The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control without the use of any centrally hardwired switching equipment (relay panels). The system's control shall be exerted by directly switching lighting loads on and off and/or dimming 0-10 VDC dimmable drivers.

2.1 MANUFACTURERS

This specification is based on the nLight® Control System from Sensor Switch, Inc. (800-727-7483, www.sensorswitch.com). Systems wishing to be substituted must be submitted no less than 5 days prior to bid date. An AutoCAD drawing of the facility showing coverage patterns and technical data must be provided with substitution request. All substitutions must clearly identify any and all exceptions to the specifications, with a detailed explanation as to the exception. If substitution is approved, the contractor shall bear the responsibility of a fully functional system to the owner's and an Architect's satisfaction. Acceptable equals:

1. nLight
2. Wattstopper DLM system.
3. Cooper Industries, Greengate.
4. **Preferred Brand Alternate No. 9:** Johnson Controls

2.2 QUALITY ASSURANCE

A. The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.
B. All applicable products must be UL and CUL or CSA Listed.
C. Product must be manufactured in the USA and be warranted for 5 years.

PART 3 – PRODUCTS

3.1 GENERAL SYSTEM SPECIFICATIONS

The following sections describe the features which the lighting control system shall possess as a complete operational system. Individual device features and specifications are listed in section 2.02.

3.2 SYSTEM ARCHITECTURE

A. All switching relays shall be located within either a sensor device, single gang wall switch device, or power (relay) pack device.
B. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located device).
C. System shall have a primary wall mounted network control "gateway" device that is capable of accessing and controlling all other system devices and linking into an Ethernet LAN.
D. System shall use "bridge" devices that route communication and distribute power for up to 8 lighting zones together for purposes of decreasing system wiring requirements.
E. System shall be able to utilize ZigBee® wireless mesh networking to facilitate communication with management software.
F. All devices within a single lighting zone shall be capable of being daisy-chain wired with CAT-5 low voltage cabling.
G. Communication and Class 2 system power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors. All cabling shall be installed by contractor providing lighting control system.
H. All system devices shall have at least two RJ-45 ports.
I. All wall mounted user control / gateway devices shall be low voltage, fit within a two gang switch box, and have a backlit LCD panel. User control shall be made available via finger-touch buttons with no moving parts.
J. System must have a web-based software management program that enables system control, status monitoring, and creation of lighting control profiles.
K. Each control gateway device shall be capable of linking 400 devices to the management software.
L. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure or the management software becoming unavailable.

3.3 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system can be made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network gateway device and on the software's host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

3.4 MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.

E. Up to 40 simultaneous user sessions shall be capable of being supported.

F. Software shall require all users to login with a Username and Password.

G. Software shall provide at least three permission levels for users.

H. All sensitive stored information and privileged communication by the software shall be encrypted.

I. All device firmware and system software updates must be available for automatic download and installation via the internet.

3.5 COMMISSIONING FEATURES

A. To facilitate commissioning, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.

B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. All system devices shall be capable of being given user defined names.

E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

F. Manufacturer shall commission final product including all programming, zone set up, and owner training sessions. Session training shall include up to (2) days of 8-hour training of facility personnel.

3.6 INDIVIDUAL DEVICE SPECIFICATIONS

The lighting control system outlined above shall consist of only devices of the following types; occupancy sensors, daylight (photocell) sensors, wall switches, dimming switches, power (relay) packs, power supplies, communication bridges, network control gateways. Panel based relay devices are not acceptable.

3.7 Occupancy & Photocell Sensors

A. General Specifications

1 Occupancy sensing technologies shall be completely passive meaning that they will not emit any radiation that is known to interfere with certain types of hearing aides, or electronic devices such as electronic white board readers. Passive Infrared (PIR) or PIR/Microphonic Dual Technology detection technologies shall be acceptable. Ultrasonic or Microwave based sensing technologies shall not be accepted.

2 Sensors shall be available with zero, one, or two integrated Class 1 switching relays.

3 Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.

4 Sensors shall be available in multiple lens options which are customized for specific applications.

5 Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

6 All sensors shall have two RJ-45 ports.

7 Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

8 Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.

9 Sensors shall be equipped with an automatic override for 100-hour burn-in of lamps. This feature must be available at any time for lamp replacements.

B. Wall Switch Sensors

1 Sensor shall recess into single-gang switch box and fit a standard GFI opening.

2 Sensor must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

3 Sensor shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

4 Sensors shall be available in four colors (Ivory, White, Almond, Gray)

C. Ceiling & Corner Mount Sensors

1 Sensor shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
2 Sensors with dimming control can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).
3 All sensors have at least one or two occupancy poles, each of which provides a programmable time delay

D. Daylight (Photocell) Sensors

1. Sensor shall provide for an On/Off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
2. Sensors' set-point and deadband shall be automatically calibrated through the sensor's micro-controller by initiating the "Automatic Set-point Programming" subroutine. Further adjustment may be made manually if needed. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
3. Sensors with dimming control can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).
4. Photocell sensor's set point shall be automatically calibrated through the sensor's micro-controller by initiating the "Automatic Set-point Programming" subroutine. Min and Max dim settings as well as set-point may be manually entered.
5. Dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be controlled as an "offset" from the primary zone and shall be the zone farthest from the natural light source.

E. Power (Relay) Packs and Supplies

1. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
2. All devices shall have two RJ-45 ports.
3. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
4. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
5. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
6. Power Pack shall incorporate a Class 1 relay and contribute low voltage power to the rest of the system. Slave Packs shall incorporate the relay but shall not be required to contribute system power. Power Supplies shall provide system power only but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
7. Class 1 Relays used in Power (Slave) Packs shall provide 16 Amp switching of all load types and be rated for 400,000 cycles.
8. Power packs shall be supplied with supplemental relays where HVAC interface is required.

F. Wall Switches & Dimmers

1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Devices shall provide user control via touch sensitive buttons that utilize no mechanical parts.
3. Devices shall be available with zero or one integrated Class 1 switching relay.
4. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
5. All sensors shall have two RJ-45 ports.
6. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
7. Devices shall be available in four colors (Ivory, White, Almond, Gray).
8. Devices with dimming control outputs can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).

G. Scene Controller

1. Device shall recess into single-gang switch box and fit a standard GFI opening.
2. Device shall provide user control via touch sensitive buttons which have no mechanical parts.
3. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. All sensors shall have two RJ-45 ports.
5. Device shall have four touch sensitive buttons for selecting programmable lighting control profiles.
6. Device shall have four LEDs indicating current selection.

H. Communication Bridges

1 Device shall surface mount to a standard 4” x 4” square junction box.
2 Device shall have either 4 or 8 RJ-45 ports.
3 Device shall be capable of aggregating communication with connected daisy-chains of system devices.
4 Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.
5 Device shall be capable of communicating with other system devices using the ZigBee® wireless mesh networking standard.
6 Provide (4) additional bridges for future use.

I. Network Control Gateway

1 Device shall recess into a two-gang switch box.
2 Device shall provide user control via touch sensitive buttons which have no mechanical parts.
3 Device shall have a backlit LCD panel.
4 Device shall contain a real-time clock capable of synchronization with a network time authority.
5 Device shall be capable of communicating on an Ethernet network with a fixed or DHCP assigned IP address.
6 Device shall have three RJ-45 ports for connection to system devices and one RJ-45 port for connection to Ethernet network.
7 Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.

3.8 HARDWARE

A. LIGHT ENERGY MANAGER (LEM)

1. The LEM power supply shall be protected from power line surges per IEEE specification 62.41 for category a locations.
2. Each LEM shall support 8 independent configurations. It shall be possible for the user to program unique schedules and settings for each configuration. Each room may then be assigned to one of the configurations via the local wall station so that no knowledge of installation details (such as data wiring or power circuiting) shall be required for configuration. Advanced settings that may be configured via the LEM include:

   a. Occupancy Sensor behavior:

      1) Manual ON/Automatic OFF (default)
      2) Automatic ON/Automatic OFF
      3) Set lights to minimum when no motion is detected during scheduled ON times and to OFF when no motion is detected during scheduled of times.

   b. Wall station, photocell and occupancy sensors may be disabled by schedule
   c. Time schedules may be temporarily suspended for 1, 2, 4, 8, 12, or 24 hours to accommodate special events. At the end of this period, the system shall automatically revert to the normal schedules.

3. Occupied Period Scheduling: The system shall support both fully adaptive and manually programmed time-of-day schedules.

   a. Adaptive Scheduling: the system shall have the ability to automatically adapt the time clock schedule to the actual use of each room in the space without requiring the use of occupancy sensors or manual programming of the system beyond setting the project location.
   b. Manual Scheduling: the system shall also have the ability to have schedules manually programmed if required.

      1) The system shall support 8 independent schedules which may be programmed with the following events:

         a) ON
         b) OFF
         c) Cancel Switch Timeouts

      2) Scheduled events may be programmed to occur at a fixed time of the day or at the calculated Sunrise and Sunset times. It shall also be possible to schedule an event to occur up to 120 minutes before or after Sunrise or Sunset.
      3) Schedule events may be programmed to occur on individual or multiple days of the week facilitating a rotating Monday through Sunday weekly operating scenario.
      4) Schedule events may also be assigned to occur on a holiday. Holiday events shall automatically supersede assigned weekday schedules based on a list of holiday dates. Holiday dates may be programmed to reoccur automatically each year or only on a specific year.

c. For both schedule types, of events shall be preceded by a warning sequence to warn the occupants of the impending of event. To maximize lamp life for loads with drivers, this warning sequence shall not turn of and re-strike the lamps, but rather dim them to minimum, then maximum, then return them to their previous level. The warning sequence shall turn non-dim loads of and then back ON again. It shall be possible to disable this warning sequence on a room-by-room basis if necessary to accommodate HID loads.

4. Load Shed Schedule: The LEM shall support a dedicated load shed schedule which allows the owner to shed from 1% to 85% of the lighting load on a time-of-day basis. When in effect, the load shed event shall proportionally subtract the programmed amount from the current occupant-set or schedule-set level. All other occupant and system controls shall remain operational during this time, but the actual level of the lights shall be the set level minus the load shed percentage.
5. Program Backup: The user program shall be stored in nonvolatile memory. The program memory shall be integrated into the device, be maintenance free, and not require batteries for retention of memory.
6. Pre-set load level "High Trim" for all classrooms. The commissioning agent or factory representative shall be able to adjust the driver factor or maximum percentage of input power that the connected smart junction box drivers will consume so that the lighting power density for a given space can be easily tailored by authorized personnel without changing the lighting fixture layout. The means to set this maximum input power percentage shall be located behind a hinged locking door and it shall not be possible for the occupants to adjust this setting.
7. Network Connections: The LEM shall be equipped with the following connections:

   a. lighting control network
   b. BACnet/IP over 10/100base-T Ethernet with two ports and integral switch.
   c. EIA RS-485 port for connection to up to 16 SYRS series digital remote stations
   d. EIA RS-232 port
   e. Onboard modem for remote monitoring and programming of the system.

8. Low Voltage Inputs: The LEM shall be equipped with the following inputs:

   a. Dry contact: programmable to accept maintained, momentary, normally open, or normally closed contacts.
   b. Analog: 3 wire, 0-10V analog input with 24VDC supply compatible with Synergy LSA APS series photocells.

PART 4 - EXECUTION

4.1 EQUIPMENT INSTALLATION AND DOCUMENTATION

A. Installation – The control system shall be installed and connected as shown on the plans and as directed by the manufacturer. The contractor shall complete all electrical connections to all control circuits, network terminations, RS-232 connections, sensors and override wiring.

B. Telephone Lines – The contractor shall arrange for all required telephone lines and touch-tone telephone override wiring as shown on the plans. All phone connections shall be terminated into a RJ-11 modular telephone connector. If multiple lines are required, they shall be installed on a rotating line such that when one line is busy the call will automatically switch to the next line.

C. Documentation – Contractor shall provide accurate "as built" drawings to the owner indicating correct and latest program information.

D. Operation and Service Manuals – Provide operation and service manuals for all components as indicated in the General Provisions.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. Timed sensors shall be set to the midpoint of their range of the time limit setting.
2. Daylight sensors be set to 100% of the required lighting level for the room they are in, typical set marks classroom: 50fc, corridors: 30fc, multipurpose rooms: 50fc. Dimmable drivers shall be set at reductions according to manufacturer or 20% per setting.

4.2 PRODUCT SUPPORT AND SERVICE

A. System Start-up

1. Provide a factory authorized technician to verify the installation, test the system, and train the owner on proper operation and maintenance of the system. Before requesting start-up services, the installing contractor shall verify that:

   a. The control system has been fully installed in accordance with manufacturer's installation instructions.

   b. Phone lines have been checked for dial tone.

   c. Low voltage wiring for overrides and sensors is completed.

   d. Any schedules or settings specified by the owner have been fully documented and supplied to the factory at time start-up is scheduled.

2. Proper notification of the impending start-up has been provided to the owner's representative.

4.3 FACTORY SUPPORT

A. Factory telephone support shall be available at no cost to the owner for the life of the system. Factory Assistance shall consist of assistance in solving programming or other application issues pertaining to the control equipment. The Factory shall provide a toll-free number for technical support.

END OF SECTION

SECTION 26 09 43

NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a networked lighting control system comprised of the following components:
1. System Software Interfaces
    a. Management Interface
    b. Historical Database and Analytics Interface
    c. Visualization Interface
    d. Personal Control Applications
2. System Backbone and Integration Equipment
    a. System Controller
3. Wired Networked Devices
    a. Wall Stations
    b. Graphic Wall Stations
    c. Digital Key Switches
    d. Auxiliary Input/Output Devices
    e. Occupancy and Photocell Sensors
    f. Wall Switch Sensors
    g. Embedded Sensors
    h. Power Packs and Secondary Packs
    i. Networked Luminaires
    j. Relay and Dimming Panel
    k. Communication Bridge

B. The networked lighting control system shall meet all of the characteristics and performance requirements specified herein.

C. The contractor shall provide, install and verify proper operation of all equipment necessary for proper operation of the system as specified herein and as shown on applicable drawings.

1.2 DEFINITIONS

A. BMS: Building management systems

B. LCS: The term ‘Lighting Control System is defined as the interconnected set of hardware and software components that collectively serve to regulate the illumination levels of an interior and/or exterior space. The components that comprise the LCS are sub categorized into three groups: LCS Input Devices, LCS End Devices and LCS Control devices.

1.3 ACTION SUBMITTALS

A. Product data:

1. Product Specification Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.

B. Complete list of Bill of Materials necessary to install the networked lighting control system.

C. Shop Drawings: Submittal shall be provided including the following items.
   1. Riser Diagrams showing device wiring connections of system backbone and typical per room/area type.
   2. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.
   3. Other Diagrams and Operational Descriptions – as needed to indicate system operation or interaction with other system(s).
   4. Contractor Startup/Commissioning Worksheet (must be completed prior to factory start-up).
   5. Service Specification Sheets indicating general service descriptions, including startup, training, post-startup support, and service contract terms.
   6. Hardware and Software Operation Manuals.

D. Provide all manufacturer warranty dates, registration documents and information.

1.4 INFORMATION SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
   1. Show interconnecting signal and control wiring, and interface devices that prove compatibility of inputs and outputs.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.
   1. Describe system features, operation and architecture in electronic and printed documentation. Include user account information, network access information and technical support contact information.

B. Software Operational Documentation:
   1. Software operating 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.

1.6 WARRANTY

A. The manufacturer shall provide a minimum five-year warranty on all hardware devices supplied and installed. Warranty coverage shall begin on the date of shipment.

B. The hardware warranty shall cover repair or replacement any defective products within the warranty period.

1.7 DELIVERY, STORAGE AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Include installation, programming, and maintenance instructions.

C. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
   1. Ambient temperature:
      a. Lighting Control System: 0 degrees to 40 degrees C (32 degrees to 104 degrees F).
      b. System server/computer: 10 degrees to 35 degrees C (50 degrees to 90 degrees F)
      c. Relative humidity: Maximum 90 percent, non-condensing.

D. All components of the LCS must be protected from dust during installation.

E. Do not install products under environmental conditions outside manufacturer's absolute limits.

F. Do not install sensors until building is operating at ambient temperature and humidity ranges that are consistent with those intended for buildings ultimate use.

1.8 QUALITY ASSURANCE

A. Product Qualifications
   1. System electrical components shall be listed or recognized by a nationally recognized testing laboratory (e.g., UL, ETL, or CSA) and shall be labeled with required markings as applicable.
   2. System shall be listed as qualified under DesignLights Consortium Networked Lighting Control System Specification V2.0.
   3. System luminaires and controls are certified by manufacturer to have been designed, manufactured and tested for interoperability.
   4. All components shall be subjected to 100% end of line testing prior to shipment to the project site to ensure proper device operation.
   5. All components and the manufacturing facility where product was manufactured must be RoHS compliant.

B. Installation and Startup Qualifications
   1. System startup shall be performed by qualified personnel approved or certified by the manufacturer.

C. Service and Support Requirements
   1. Phone Support: Toll free technical support shall be available.
   2. Remote Support: Remote support capability shall be provided.
   3. Onsite Support: Onsite support that is billable at whole day rates.
   4. Service Contract: Service Contract that packages phone, remote, and onsite support calls for the project. Response times for each type of support call shall be indicated in the terms of the service contract included in the bid package.

D. The manufacturer shall make available to the owner new parts, upgrades, and/or replacements available for a minimum of 5 years following installation.

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Acceptable Manufacturers Any alternate product or system that has not received prior approval from the owner's representative at least 10 days prior to submission of a proposal package shall be rejected. Provide product by one of the following:
   1. Basis of Design System: Hubbell NX Distributed Intelligence
   2. Acuity Controls nLight
   3. Wattstopper DLM

2.2 SYSTEM COMPLIANCE

A. System components shall comply with UL 916 and UL 924 standards where applicable.

B. System components shall comply with CFR Title 47, Part 15 standards where applicable.

C. All equipment shall be installed and connected in compliance with NFPA 70.

2.3 SYSTEM PERFORMANCE REQUIREMENTS

A. System Architecture
   1. System shall have an architecture that is based upon three main concepts: (1) networkable intelligent lighting control devices, (2) standalone lighting control zones using distributed intelligence, (3) optional system backbone for remote, time based and global operation between control zones.
   2. Intelligent lighting control devices shall have individually addressable network communication capability and consist of one or more basic lighting control components: occupancy sensor, photocell sensor, relay, dimming output, contact closure input, analog 0-10V input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure shall be permissible so as to minimize overall device count of system.
   3. System must be capable of interfacing directly with networked luminaires such that either low voltage network cabling or wireless RF communication is used to interconnect networked luminaires with control components such as sensors, switches and system backbone.
   4. Lighting control zones consisting of one or more networked luminaires and intelligent lighting control devices and shall be capable of providing automatic control from sensors (occupancy and/or photocell) and manual control from local wall stations without requiring connection to a higher-level system backbone; this capability is referred to as "distributed intelligence."
      a. Lighting control zones (wired and wireless) of at least 128 devices per zone shall be supported.
   5. Networked luminaires and intelligent lighting control devices shall support individual (unique) configuration of device settings and properties, with such configuration residing within the networked luminaires and intelligent control devices.
   6. Networked luminaires and intelligent lighting control devices shall have distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones shall operate according to their defined default settings and sequence of operations.
   7. Lighting control zones shall be capable of being networked with a higher-level system backbone to provide time-based control, remote control from inputs and/or systems external to the control zone, and remote configuration and monitoring through a software interface.
   8. The system may include one or more system controllers that provide time-based control and global system control across multiple control zones and backbone network segments. The system controller also provides a means of connecting the lighting control system to a system

software interface and building management systems via BACnet/IP or BACnet MS/TP protocol.

9. The system may include “communication bridge” devices that route communication from lighting control zones (wired or wireless) to and from the system controller, for purposes of decreasing system wiring requirements.
10. All system devices shall support remote firmware update, such that physical access to each device is not necessary, for purposes of upgrading functionality at a later date.

B. Wired Networked Control Zone Characteristics

1. Connections to devices within a wired networked lighting control zone and to backbone components shall be with a single type of low voltage network cable, which shall be compliant with CAT5e specifications or higher. To prevent wiring errors and provide cost savings, the use of mixed types of low voltage network cables shall not be permitted.
2. Devices in an area shall be connected via a “daisy-chain” topology; requiring all individual networked devices to be connected back to a central component in a “hub-and-spoke” topology shall not be permitted, so as to reduce the total amount of network cable required for each control zone.
3. System shall provide the option of having pre-terminated plenum rated low voltage network cabling supplied with hardware so as to reduce the opportunity for improper wiring and communication errors during system installation.
4. Following proper installation and provision of power, all networked devices connected together with low voltage network cable shall automatically form a functional lighting control zone without requiring any type of programming, regardless of the programming mechanism (e.g., software application, handheld remote, pushbutton). The “out of box” default sequence of operation is intended to provide typical sequence of operation so as to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.
5. Once software is installed, system shall be able to automatically discover all connected devices without requiring any provisioning of system or zone addresses.
6. All networked devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.
7. Networked control devices intended for control of egress and/or emergency light sources shall not require the use of additional, externally mounted UL924 shunting and/or 0-10V disconnect devices, so as to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. The following types of wired networked control devices shall be provided for egress and/or emergency light fixtures:
    a. Low-Voltage power sensing: These devices shall automatically provide 100% light level upon detection of loss of power sensed via the low voltage network cable connection.
    b. UL924 Listed Line-Voltage power sensing: These devices shall be listed as emergency relays under the UL924 standard, and shall automatically close the load control relay and provide 100% light output upon detection of loss of power sensed via line voltage connection to normal power.

C. System Integration Capabilities

1. The system shall interface with third party building management systems (BMS) to support two-way communication using the industry standard BACnet/IP or BACnet MS/TP protocols. The following system integration capabilities shall be available via BACnet/IP and BACnet MS/TP protocols:
    a. The system shall support control of individual devices, including, but not limited to, control of relay and dimming output.

b. The system shall support reading of individual device status information. The available status will depend on the individual device type and capabilities, which may include but not be limited to, relay state, dimming output, power measurement, occupancy sensor status, and photocell sensor states or readings. All system devices shall be available for polling for devices status.

2. The system shall support activation of Profiles (local or global) and Preset Scenes from third party systems by receiving dry contact closure output signals or digital commands via RS-232/RS-485.
3. The system shall support activation of demand response levels from Demand Response Automation Servers (DRAS) via the OpenADR 2.0a protocol.

D. Supported Sequence of Operations
1. Characteristics and performance requirements herein shall be supported by the networked lighting control system.
2. Control Zones
   a. Networked luminaires and intelligent lighting control devices installed in an area (also referred to as a group of devices) shall be capable of transmitting and tracking occupancy sensor, photocell sensor, and manual switch information within at least 48 unique control zones to support different and reconfigurable sequences of operation within the area. These shall also be referred to as local control zones.
   b. Networked luminaires and intelligent lighting control devices located in different areas shall be able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span across multiple areas. Occupancy and photocell commands shall be available across a single controller, and switch commands shall be available across single or multiple controllers. These shall also be referred to as global control zones.
3. Wall station Capabilities
   a. Wall stations shall be provided to support the following capabilities:
      1) On/Off of a local control zone and global control zone simultaneously, as required.
      2) Continuous dimming control of light level of a local control zone and global control zone simultaneously, as required.
      3) Preset Scenes that can activate a specific combination of light levels across multiple local and global channels, as required.
      4) Profile Scenes that can modify the sequence of operation for the devices in the area (group) in response to a button press. This capability is defined as supporting "Local Profiles" and is used to dynamically optimize the occupant experience and lighting energy usage. Wall stations shall be able to manually start and stop Local Profiles, or the local profile shall be capable of ending after a specific duration of time between 5 minutes and 12 hours. Parameters that shall be configurable and assigned to a Local Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.
   b. 3-way / multi-way control: multiple wall stations shall be capable of controlling the same local and global control zones, so as to support "multi-way" switching, dimming, preset scene, and profile scene control.
4. Occupancy Sensing Capabilities
   a. Local and global control: Occupancy sensors shall be configurable to control a local and global zone simultaneously, as required.

b. Multi-sensor control: multiple occupancy sensors shall be capable of controlling the same local and global control zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
c. System shall support the following types of occupancy sensing sequence of operations:
    1) On/Off Occupancy Sensing
    2) Partial-On Occupancy Sensing
    3) Partial-Off Occupancy Sensing
    4) Vacancy Sensing (Manual-On / Automatic-Off)
d. On/Off, Partial-On, and Partial-Off Occupancy Sensing modes shall function according to the following sequence of operation:
    1) Occupancy sensors shall automatically turn lights on to a designated level when occupancy is detected. To support fine tuning of Partial-On sequences the designated occupied light level shall support at least 100 dimming levels.
    2) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. To support fine tuning of Partial-Off sequences the designated unoccupied dim level shall support at least 100 dimming levels. To provide additional energy savings and an enhanced occupant experience, the system shall also be capable of dimming the lights when vacant and then turning the lights off completely after an additional amount of time.
    3) Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage.
    4) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.
e. Vacancy Sensing mode (also referred to as Manual-On / Automatic-Off) shall function according to the following sequence of operation:
    1) The use of a wall station is required turn lights on. The system shall be capable of programming the zone to turn on to either to a designated light level or the previous user light level. Initially occupying the space without using a wall station shall not result in lights turning on.
    2) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. To support fine tuning of Partial-Off sequences the designated unoccupied dim level shall support at least 100 dimming levels. To provide additional energy savings and an enhanced occupant experience, the system shall also be capable of dimming the lights when vacant and then turning the lights off completely after an additional amount of time.
    3) To minimize occupant impact in case the area or zone is still physically occupied following dimming or shutoff of the lights due to detection of vacancy, the system shall support an "automatic grace period" immediately following detection of vacancy, during which time any detected occupancy shall result in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.
    4) Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage.

5) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

f. To accommodate different types of environments, occupancy time delays before dimming or shutting off lights shall be specifiable for control zones between 15 seconds to 2 hours.

5. Schedule and Global Profile Capabilities

a. The system shall be capable of automatically modifying the sequence of operation for selected devices in response to any of the following: a time-of-day schedule, contact closure input state, manually triggered wall station input, RS-232/RS-485 command, and BACnet input command. This capability is defined as supporting "Global Profiles" and is used to dynamically optimize the occupant experience and lighting energy usage.

b. Global profiles may be scheduled with the following capabilities:

1) Global Profiles shall be stored within and executed from the system controller (via internal timeclock) such that a dedicated software host or server is not required to be online to support automatic scheduling and/or operation of Global Profiles.

2) Global Profile time of day schedules shall be capable of being given the following recurrence settings: daily, specific days of week, every "n" number of days, weekly, monthly, and yearly. Lighting control profile schedules shall support definition of start date, end date, end after "n" recurrences, or never ending. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

3) Global Profile Holiday Schedules should follow recurrent settings for specific US holiday dates regardless if they always occur on a specific date or are determined by the day/week of the month.

4) Global Profiles shall be capable of being scheduled to run according to timed offsets relative to sunrise or sunset. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

5) System shall support blink warning and timed extension capabilities. At the end of a scheduled period, the system shall be capable of providing a visible "blink warning" 5 minutes prior to the end of the schedule. Wall stations may be programmed to provide timed overrides that turn the lights on for an additional period of time. Timed override duration shall be programmable for each individual device, zone of devices, or customized group of devices, ranging from 5 minutes to 12 hours.

6) Software management interface shall be capable of displaying a graphic calendar view of profile schedules for each control zone.

c. System Global Profiles shall have the following additional capabilities:

1) Global Profiles shall be capable of being manually activated directly from the system controller, specially programmed input devices, scene capable wall stations, and the software management interface.

2) Global Profiles shall be selectable to apply to a single device, zone of devices, or customized group of devices.

3) Parameters that shall be configurable and assigned to a Global Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.

d. A backup of Local and Global Profiles shall be stored on the software's host server such that the Profile backup can be applied to a replacement system controller or wall station.

6. System shall support automated demand response capabilities with automatic reduction of light level to at least three levels of demand response.

2.4 SYSTEM SOFTWARE INTERFACES

A. Management Interface

1. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.
2. Management interface must be compatible with industry-standard web browser clients, including, but not limited to, Microsoft Internet Explorer®, Apple Safari®, Google Chrome®, Mozilla Firefox®.
3. Management interface shall require all users to login with a Username and Password, and shall support creation of at least 100 unique user accounts.
4. Management interface shall support at least three permission levels for users: read-only, read & change settings, and full administrative system access.
5. Management interface shall be capable of restricting access for user accounts to specific devices within the system.
6. All system devices shall be capable of being given user-defined names.
7. The following device identification information shall be displayed in the Management interface: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
8. Management interface shall be able to read the live status of a networked luminaire or intelligent control device and shall be capable of displaying luminaire on/off status, dim level, power measurement, device temperature, PIR occupancy sensor status, microphonic occupancy sensor status, remaining occupancy time delay, photocell reading, and active Scenes or Profiles.
9. Management interface shall be able to read the current active settings of a networked luminaire or intelligent control device and shall be capable of displaying dimming trim levels, occupancy sensor and photocell enable/disable, occupancy sensor time delay and light level settings, occupancy sensor response (normal or vacancy), and photocell setpoints and transition time delays.
10. Management interface shall be able to change the current active settings and default settings for an individual networked luminaire or intelligent control device.
11. Management interface shall be capable of applying settings changes for a zone of devices or a group of selected devices using a single "save" action that does not require the user to save settings changes for each individual device.
12. A printable network inventory report shall be available via the management interface.
13. A printable report detailing all system profiles shall be available via the management interface.
14. All sensitive information stored by the software shall be encrypted.
15. All system software updates must be available for automatic download and installation via the internet.

B. Historical Database and Analytics Interface

1. System shall provide a historical database that stores device operational history and calculates energy usage for all networked luminaires and intelligent control devices.

2. System shall be capable of reporting lighting system events and performance data back to the historical database for display and analysis.
3. Historical database shall be capable of recording historical data for up to 20,000 networked devices for a period of at least 1 calendar year.
4. An “Energy Scorecard” shall be displayed that shows calculated energy savings in dollars, kWh, or CO2.
5. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc.).
6. Energy savings data shall be calculated for the system as a whole or for individual zones.
7. A time scaled graph showing all relay transitions shall be presented.
8. A time scaled graph showing a zones occupancy time delay shall be presented
9. A time scaled graph showing the total light level shall be presented.
10. User shall be able to customize the baseline run-time hours for a space.
11. User shall be able to customize up to four time-of-day billing rates and schedules.
12. Historical data shall be exportable from the Historical Database via a “CSV” type of file format.

C. Visualization and Programming Interfaces
1. System shall provide a web-based visualization interface that displays graphical floorplan.
2. Graphical floorplan shall offer the following types of system visualization:
    a. Full Device Option - A master graphic of the entire building, by floor, showing each control device installed in the project with zones outlined. This shall include, but not be limited to, the following:
        1) Controls embedded light fixtures
        2) Controls devices not embedded in light fixtures
        3) Daylight Sensors
        4) Occupancy Sensors
        5) Wall Switches and Dimmers
        6) Scene Controllers
        7) Networked Relays
        8) Bridges
        9) System Controllers
        10) Panels
        11) Zone outlines
    b. Zone Only Option - A master graphic of the entire building, by floor, showing only control zones outlined.
    c. Allow for pan and zoom commands so smaller areas can be displayed on a larger scale simply by panning and zooming each floor’s master graphic.
    d. A mouse click on any control device shall display the following information (as applicable):
        1) The device catalog number.
        2) The device name and custom label.
        3) Device diagnostic information.
        4) Information about the device status or current configuration is available with an additional mouse click.

D. Personal Control Applications
1. Software interface shall support personal control software applications that provide user-specific control of individual luminaires/control devices, control zones, global scene presets, and scene selector virtual button presses.

2. The system administrator shall be capable of defining personal control permissions for each user account.
3. Software interface shall provide a Microsoft Windows® operating system taskbar application for personal lighting control.
4. Software interface shall provide an Apple iOS ® operating system application (supported by mobile phones and mobile tablet devices) for personal lighting control.

2.5 SYSTEM BACKBONE AND SYSTEM INTEGRATION EQUIPMENT

A. System Controller
1. System Controller shall be multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
2. System Controller shall have 32-bit microprocessor operating at a minimum of 1 GHz.
3. System Controller shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases.
4. System Controller shall perform the following functions:
   a. Time-based control of downstream wired and wireless network devices.
   b. Facilitation of global network switch communication between different system controllers.
   c. Linking into an Ethernet network.
   d. Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
   e. Connection to various software interfaces, including management interface, historical database and analytics interface, visualization interface, and personal control applications.
5. System Controller shall have an integral web server to support configuration, diagnostics and hosting of software interfaces.
6. Device shall have option for a graphical touch screen to support configuration and diagnostics.
7. Device shall have three RJ-45 networked lighting control ports for connection to any of the following:
   a. The graphical touch screen
   b. Wired communication bridges
   c. Direct connection to networked wired luminaires and intelligent lighting control devices (up to 128 total devices per port)
8. Device shall be capable of communicating with wireless network bridges and software interfaces via LAN connection.
9. Device shall automatically detect all networked devices connected to it, including those connected to wired and wireless communication bridges.
10. Device shall have a standard and astronomical internal time clock.
11. Device shall have 2 switched RJ-45 10/100 BaseT Ethernet ports for local area network (LAN) connection.
    a. Ethernet connection shall support daisy chain wiring to other lighting control system LAN devices, such as other system controllers and wireless networked communication bridges.
    b. Ethernet connection shall support IPv4 and shall be capable of using a dedicated static or DHCP assigned IP address.
12. Device shall have 2 x USB 2.0 Expansion ports for 802.11 Wi-Fi Adapter enabling wireless connectivity including:
    a. Hot Spot

b. Access Point
c. Client

13. Each System Controller shall be capable of managing and operating at least 750 networked devices (wired or wireless).
    a. Multiple System Controllers may be networked together via LAN connection to scale the system up to 20,000 networked devices.
14. System Controller shall support BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without the need for additional protocol translation gateways.
    a. BACnet MS/TP shall support 9600 to 115200 baud rate.
    b. System Controller shall be BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.
15. System controller shall contain a “FIPS 140-2 Level 1 Inside” cryptographic module.
16. System controller shall be available within a NEMA 1 enclosure with Class 1 and Class 2 separation
    a. Enclosure shall support power input power of 120-277VAC, or optional 347VAC

2.6 WIRED NETWORKED DEVICES

A. Wired Networked Wall Switches, Dimmers, Scene Controllers
1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
3. All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
4. Devices with mechanical pushbuttons shall provide tactile and LED user feedback.
5. Devices with mechanical pushbuttons shall be made available with custom button labeling.
6. Wall switches & dimmers shall support the following device options:
    a. Number of control zones: 1, 2 or 4
    b. Control Types Supported:
        1) On/Off
        2) On/Off/Dimming
        3) On/Off/Dimming/Correlated Color Temperature Control for specific luminaire types
    c. Colors: Ivory, White, Light Almond, Gray, Black, Red as required by architect
7. Scene controllers shall support the following device options:
    a. Number of scenes: 1, 2 or 4
    b. Control Types Supported:
        1) On/Off
        2) On/Off/Dimming
        3) Preset Level Scene Type
        4) On/Off/Dimming/Preset Level for Correlated Color Temperature
        5) Reprogramming of other devices within daisy-chained zone so as to implement user selected lighting scene. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
        6) Selecting a lighting profile to be run by the system’s upstream controller so as to implement a selected lighting profile across multiple zones. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.

c. Colors: Ivory, White, Light Almond, Gray, Black, Red as required by architect

B. Wired Networked Graphic Wall Stations
1. Device shall surface mount to single-gang switch box.
2. Device shall have a 3.5” full color touch screen.
3. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.
4. Device shall have a micro-USB style connector for local computer connectivity.
5. Communication shall be over standard low voltage network cabling with RJ-45 connectors.
6. Device shall enable user supplied screen saver image to be uploaded within one of the following formats: jpg, png, gif, bmp, tif.
7. Device shall enable configuration of all switches, dimmers, and lighting preset scenes via password protected setup screens.
8. Graphic wall stations shall support the following device options:
    a. Number of control zones: Up to 16
    b. Number of scenes: Up to 16
    c. Profile type scene duration: User configurable from 5 minutes to 12 hours
    d. Colors: Ivory, White, Light Almond, Gray, Black as required by architect

C. Wired Networked Auxiliary Input / Output (I/O) Devices
1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
2. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
3. Auxiliary Input/Output Devices shall be specified as an input or output device with the following options:
    a. Contact closure or Pull High input
        1) Input shall be programmable to support maintained or momentary inputs that can activate local or global scenes and profiles, activate lights at a preconfigured level, ramp light level up or down, or toggle lights on/off.
    b. 0-10V analog input
        1) Input shall be programmable to function as a daylight sensor.
    c. RS-232/RS-485 digital input
        1) Input supports activation of up to 4 local or global scenes and profiles, and on/off/dimming control of up to 16 local control zones.
    d. 0-10V dimming control output, capable of sinking up to 20mA of current
        1) Output shall be programmable to support all standard sequence of operations supported by system.

D. Wired Networked Occupancy and Photosensors
1. Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional “dual” technology shall be used.
4. Dual technology sensors shall have one of its two technologies do not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for

sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.

5. All sensing technologies shall be acoustically passive, meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
6. System shall have ceiling, fixture, recessed & corner mounted sensors available, with multiple lens options available customized for specific applications.
7. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
8. All sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
9. Sensor programming parameter shall be available and configurable remotely from the software and locally via the device push-button.
10. Ceiling mount occupancy sensors shall be available with zero or one integrated dry contact switching relays, capable of switching 1 amp at 24 VAC/VDC (resistive only).
11. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.
12. Sensors shall have optional features for photosensor/daylight override, automatic dimming control, and low temperature/high humidity operation.
13. Photosensor shall provide for an on/off set-point, and a dead band to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
14. Photosensor and dimming sensor’s set-point and dead band shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.
15. Dead band setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
16. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The secondary daylight zone shall be capable of being controlled as an “offset” from the primary zone.

E. Wired Networked Wall Switch Sensors
1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
3. All wall switch sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
4. Devices with mechanical pushbuttons shall provide tactile user feedback.
5. Wall switches sensors shall support the following device options:
    a. User Input Control Types Supported: On/Off or On/Off/Dimming
    b. Occupancy Sensing Technology: PIR only or Dual Tech acoustic
    c. Daylight Sensing Option: Inhibit Photosensor
    d. Colors: Ivory, White, Light Almond, Gray as required by architect

F. Wired Networked Power Packs and Secondary Packs
1. Power Packs shall incorporate one optional Class 1 relay, optional 0-10 VDC dimming output, and contribute low voltage Class 2 power to the rest of the system.

2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC) and carry a plenum rating.
3. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power.
4. Power Supplies shall provide system power only but are not required to switch line voltage circuit.
5. Auxiliary Relay Packs shall switch low voltage circuits only, capable of switching 1 amp at 40 VAC/VDC (resistive only).
6. Communication shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors. Secondary packs shall receive low voltage power via standard low voltage network cable.
7. Power Pack programming parameters shall be available and configurable remotely from the software and locally via the device push-button.
8. Power Pack shall securely mount through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast/driver channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
9. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
10. Power/Secondary Packs shall be available with the following options:
11. Power Pack capable of full 16-Amp switching of all normal power lighting load types, with optional 0-10V dimming output capable of up to 100mA of sink current.
12. Secondary Pack with UL924 listing for switching of full 16-Amp Emergency Power circuits, with optional 0-10V dimming output capable of up to 100mA of sink current.
13. Power and Secondary Packs capable of full 20-Amp switching of general purpose receptacle (plug-load) control.
14. Secondary Pack capable of full 16-Amp switching of all normal power lighting load types.
15. Secondary Pack capable of 5-Amps switching and dimming 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
16. Secondary Pack capable of 5-Amps switching and dimming of 120/277 VAC magnetic low voltage transformers.
17. Secondary Pack capable of 4-Amps switching and dimming of 120 VAC electronic low voltage transformers.
18. Secondary Pack capable of louver/damper motor control for skylights.
19. Secondary Pack capable of providing a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
20. Secondary Pack capable of switching 1 amp at 40 VAC/VDC (resistive only) with the intent to provide relay signal to auxiliary system (e.g. BMS).
21. Power Supply capable of providing auxiliary bus power (no switched or dimmed load).

G. Wired Networked Relay and Dimming Panel
1. Relay and dimming panel shall be available with 4, 8, 12 or 16 individual relays per panel, with an equal number of individual 0-10V dimming outputs.
2. Optional Field Configurable Relays (FCR) used shall have the following required properties:
3. Configurable in the field to operate with single-, double-, or triple-pole relay groupings.
4. Configurable in the field to operate with normally closed or normally open behavior.
5. Provides visual status of current state and manual override control of each relay.

6. Listed for the following minimum ratings:
7. 40A @ 120-480VAC Ballast
8. 16A @ 120-277VAC Electronic
9. 20A @ 120-277VAC Tungsten
10. 20A @ 48VDC Resistive
11. 2HP @ 120VAC
12. 3HP @ 240-277VAC
13. 65kA SCCR @ 480VAC
14. 0-10 dimming outputs shall support a minimum of 100mA sink current per output.
15. Relay and dimming outputs shall be individually programmable to support all standard sequence of operations as defined in this specification.
16. Panel shall be UL924 listed for control of emergency lighting circuits.
17. Panel shall power itself from an integrated 120-277 VAC or optional 347VAC supply.
18. Panel shall provide a configurable low-voltage sensor input with the following properties:
19. Configurable to support any of the following input types:
20. Indoor Photocell
21. Outdoor Photocell
22. Occupancy Sensor
23. Contact Closure
24. Low voltage sensor input shall provide +24VDC power for the sensor so that additional auxiliary power supplies are not required.
25. Sensor input supports all standard sequence of operations as defined in this specification.
26. Panel shall provide a contact closure input that acts as a panel override to activate the normally configured state of all relays (i.e., normally open or normally closed) in the panel. This input is intended to provide an interface to alarm systems, fire panels, or BMS system to override the panel.
27. Panel shall supply current limited low voltage power to other networked devices connected via low voltage network cable.
28. Panel shall be available with NEMA 1 rated enclosure with the following properties:
29. Surface-mounted or flush-mounted enclosure back box
30. Screw-fastened cover or hinged cover with keyed lock
31. Panel shall be rated from 0-50C.

H. Wired Networked Communication Bridge
   1. Device shall surface mount to a standard 4” x 4” square junction box.
   2. Device shall have 8 RJ-45 ports for connection to lighting control zones (up to 127 devices per port), additional network bridges, and System Controller.
   3. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to System Controller.
   4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply, or powered via low voltage network connections from powered lighting control devices (e.g. power packs).
   5. Wired Bridge shall be capable of redistributing power from its local supply and connected lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Installation Procedures and Verification
   1. Review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.
   2. Install and connect the networked lighting control system components according to the manufacturer's installation instructions, wiring diagrams, the project submittals and plans specifications.

B. Coordination with Owner's IT Network Infrastructure
   1. Coordinate with the owner's representative to secure all required network connections to the owner's IT network infrastructure.
      a. Provide to the owner's representative all network infrastructure requirements of the networked lighting control system.
      b. Provide to the manufacturer's representative all necessary contacts pertaining to the owner's IT infrastructure, to ensure that the system is properly connected and started up.

C. Documentation and Deliverables
   1. The installing contractor shall be responsible for documenting installed location of all networked devices, including networked luminaires. This includes responsibility to provide as-built plan drawing showing device address barcodes corresponding to locations of installed equipment.
   2. The installing contractor is also responsible for the following additional documentation to the manufacturer's representative if visualization / graphical floorplan software is provided as part of bid package:
      a. As-Built floor plan drawings showing daisy-chain wired network control zones outlined, in addition to device address locations required above. All documentation shall remain legible when reproducing\scanning drawing files for electronic submission.
      b. As-Built electrical lighting drawings (reflected ceiling plan) in PDF and CAD format. Architectural floor plans shall be based on as-built conditions.
         1) CAD files shall have layers already turned on/off as desired to be shown in the graphical floorplan background images. The following CAD elements are recommended to be hidden to produce an ideal background graphical image:
            Titleblock
            Text- Inclusive of room names and numbers, fixture tags and drawings notes
            Fixture wiring and homeruns
            Control devices
            Hatching or poché of light fixtures or architectural elements
         2) CAD files shall be of AutoCAD 2013 or earlier. Revit file overall floor plan views shall be exported to AutoCAD 2013.

3.2 SYSTEM STARTUP

A. Upon completion of installation by the installer, including completion of all required verification and documentation required by the manufacturer, the system shall be started up and programmed by an authorized representative of the manufacturer.
   1. Low voltage network cable testing shall be performed prior to system startup.

B. System start-up and programming shall include:
   1. Verifying operational communication to all system devices.

2. Programming the network devices into functional control zones to meet the required sequence of operation.
3. Programming and verifying all sequence of operations.
4. Customization of owner's software interfaces and applications.

C. Initial start-up and programming is to occur on-site. Additional programming may occur on-site or as necessary.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
1. Test continuity of each circuit.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Test each bus controller using a portable PC.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Field Test Reports:
1. Printed list of all points created from actual queries of all addressed control points to include LED drivers, manual controls, and sensors.
2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.
3. Trend data for all daylight zones covering a period of not less than one week and demonstrating performance consistent with the submitted computer models for those spaces.

D. Lighting controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 CLOSEOUT ACTIVITIES

A. System Documentation
1. Submit software database file with desired device labels and notes completed. Changes to this file will not be made by the factory.

B. Owner Training
1. Provisions for onsite training for owner and designated attendees to be included in submittal package.

END OF SECTION

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes 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 nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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 IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 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: Aluminum.

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 150 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with EPAct 2005, efficiency levels.
   2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

L. 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.

M. Wall Brackets: Manufacturer's standard brackets.

N. Sound-Level Requirements: NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

O. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:
1. 30 to 50 kVA: 45db
2. 51 to 150 kVA: 50db
3. 151 to 300 kVA: 55db
4. 301 to 500 kVA: 60db
5. 501 to 750 kVA: 62db
6. 751 to 1000 kVA: 64db

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

SECTION 26 24 13

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.

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.

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. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. 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.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Qualification Data: For qualified Installer.

D. 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.

E. 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.

F. 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.
      b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

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.

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. Siemens Energy & Automation, Inc.
   4. 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: 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. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

I. 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.

J. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

K. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

L. Buses and Connections: Three phase, four wire unless otherwise indicated.
   1. Phase- and Neutral-Bus Material: 98 percent conductivity
   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-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.

M. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected 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 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-replicable 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. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
   g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   h. 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.

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. Control Voltage: 120-V ac.

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:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

2.4 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. 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.

2.6 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

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 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. Comply with NECA 1.

3.3 CONNECTIONS

A. 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."

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. Acceptance Testing Preparation:
  1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
  2. Test continuity of each circuit.

D. Tests and Inspections:
  1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  3. Perform the following infrared scan tests and inspections and prepare reports:
    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front 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 Substantial Completion.

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.

E. Switchboard will be considered defective if it does not pass tests and inspections.

F. 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.

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, PROTECTION COORDINATION AND ARC-FLASH STUDY

A. Refer to specification section 260573 for requirements.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. 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. UL listing for series rating of installed devices.
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   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. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.

B. 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."

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 NEMA PB 1.

E. 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. Siemens Energy & Automation, Inc.
      d. 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. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
5. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.
6. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
7. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.

C. Phase and Ground Buses:
1. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
2. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
4. 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. Feed-Through Lugs: Compression Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
4. 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.

2.3 PANELBOARD SHORT-CIRCUIT RATING

A. UL label indicating series-connected rating with integral or remote upstream overcurrent protective devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

B. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 DISTRIBUTION PANELBOARDS

A. Doors: Secured with vault-type latch with tumbler lock; keyed alike. Omit for fused-switch panelboards.

B. Main Overcurrent Protective Devices: Circuit breaker or Fused switch, 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.
3. Fused switches.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Plug-in 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 series-connected 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 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 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-mA trip sensitivity for personnel receptacles, kitchen, EWC, etc; 30-mA trip sensitivity for equipment connections like heat tape, drain line heaters, etc.

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. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

9. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

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 four 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-plastic nameplate mounted with corrosion-resistant screws.

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. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial 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 Substantial 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.

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.

END OF SECTION

SECTION 26 27 26

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. Pendant cord-connector devices.
10. Cord and plug sets.
11. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

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. SPD: Transient voltage surge suppressor, Surge Protection Device.

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.
   2. Receptacles shall be tamper resistant per NEC requirements. Catalog numbers listed below are minimum requirements and shall be provided as the tamper resistant version.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
   1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
   2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
   3. Leviton Mfg. Company Inc. (Leviton).
   4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. 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. Cooper; 5351 (single), 5352 (duplex).
      b. Hubbell; HBL5351 (single), CR5352 (duplex).
      c. Leviton; 5891 (single), 5352 (duplex).
      d. Pass & Seymour; 5381 (single), 5352 (duplex).

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. Cooper; TR8300.
      b. Hubbell; HBL8300SG.
      c. Leviton; 8300-SGG.
      d. 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. GFCI receptacles shall be self-testing type.

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. Cooper; L520R.
      b. Hubbell; HBL2310.
      c. Leviton; 2310.
      d. 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. Hubbell; IG2310.
      b. Leviton; 2310-IG.
   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. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
      b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
      c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
      d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

C. Pilot Light Switches, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper; 2221PL for 120 V and 277 V.
      b. Hubbell; HPL1221PL for 120 V and 277 V.
      c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
      d. 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. Cooper; 2221L.
      b. Hubbell; HBL1221L.
      c. Leviton; 1221-2L.
      d. 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. Cooper; 1995.
      b. Hubbell; HBL1557.
      c. Leviton; 1257.
      d. 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. Cooper; 1995L.
b. Hubbell; HBL1557L.
c. Leviton; 1257L.
d. 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. 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 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.

2.11 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.

2.12 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. Square D/ Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold Company (The).

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.

2.13 MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).
3. Panduit
4. AMP

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.

2.14 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.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, 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 on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

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

SECTION 26 28 13

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.

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.

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

SECTION 26 28 16

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. Molded-case circuit breakers.
   4. Enclosures.

1.3 DEFINITIONS

A. GD: General duty – NOTE: General Duty is NOT ALLOWED

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 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. 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.

E. Manufacturer's field service report.

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

B. Comply with NFPA 70.

C. 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. 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. 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 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. 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. 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 Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.4 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. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   4. Infrared Scanning:
      a. Initial Infrared Scanning: After Substantial 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 Substantial 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

SECTION 26 32 13

ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged engine-generator sets for standby 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. Fuel system.
6. Outdoor enclosure.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Seismic Qualification Certificates: For engine-generator set, 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: With engine and generator mounted on rails identify center of gravity and total weight including supplied enclosure, external silencer, subbase-mounted full fuel tank, and each piece of equipment not integral to the engine-generator set 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.

C. Source quality-control reports, including, but not limited to the following:

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. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
4. Report of sound generation.
5. Report of exhaust emissions showing compliance with applicable regulations.
6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: 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.

1. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Caterpillar; Engine Div.
2. Generac Power Systems, Inc.
3. Onan/Cummins Power Generation; Industrial Business Group.
4. Kohler

B. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine-generator set housing, engine-generator set, batteries, battery racks, silencers, and sound attenuating equipment, accessories, and components 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst case normal levels.
3. Component Importance Factor: 1.5.

B. ASME Compliance: Comply with ASME B15.1.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.

F. 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.

G. 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: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet.

2.3 ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. EPSS Class: Engine-generator set shall be classified as a Class 2 in accordance with NFPA 110.

D. Induction Method: Naturally aspirated.

E. Governor: Adjustable isochronous, with speed sensing.

F. Emissions: Comply with EPA Tier 3 requirements.

G. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

H. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
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.

I. 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 three-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.

2.4 ENGINE

A. Fuel: Diesel.

B. Rated Engine Speed: 1800 rpm.

C. 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.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

E. 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.

F. Muffler/Silencer: Critical 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. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" 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: Nicad, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
6. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for Nicad batteries. Unit shall comply with UL 1236.

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.

B. Provide minimum run time control set for 30 minutes with override only by operation of an emergency-stop switch.

C. Comply with UL 508A.

D. 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. Panel shall be powered from the engine-generator set battery.

E. 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. Panel shall be powered from the engine-generator set battery.

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.

F. Indicating Devices: As required by NFPA 110 for Level 1 system, including the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. EPS supplying load indicator.
5. Ammeter and voltmeter phase-selector switches.
6. DC voltmeter (alternator battery charging).
7. Engine-coolant temperature gage.
8. Engine lubricating-oil pressure gage.
9. Running-time meter.
10. Current and Potential Transformers: Instrument accuracy class.

G. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 1 system, including the following:

1. Start-stop switch.
2. Over-crank shutdown device.
3. Overspeed shutdown device.
4. Coolant high-temperature shutdown device.
5. Coolant low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Air shutdown damper shutdown device when used.
8. Over-crank alarm.

9. Overspeed alarm.
10. Coolant high-temperature alarm.
11. Coolant low-temperature alarm.
12. Coolant low-level alarm.
13. Low lube oil pressure alarm.
14. Air shutdown damper alarm when used.
15. Lamp test.
16. Contacts for local common alarm.
17. Coolant high-temperature pre-alarm.
18. Generator-voltage adjusting rheostat.
19. Run-Off-Auto switch.
20. Control switch not in automatic position alarm.
21. Low cranking voltage alarm.
22. Battery-charger malfunction alarm.
23. Battery low-voltage alarm.
24. Battery high-voltage alarm.
25. Generator overcurrent protective device not closed alarm.

H. 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.

I. 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.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

  1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. 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.
  4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

  1. Indicate ground fault with other generator-set alarm indications.
  2. Trip generator protective device on ground fault.

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. Provide six lead alternator.

E. Range: Provide extended range of output voltage by adjusting the excitation level.

F. 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.

G. Enclosure: Drip-proof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Walk in, vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. 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.

B. 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.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

C. Interior Lights with Switch: Factory-wired, vapor-proof 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.

D. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.9 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.10 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Equipment Mounting:

1. Install packaged engine generators on existing cast-in-place concrete equipment base.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Install engine-generator in a walk-in enclosure Secure enclosure to anchor bolts installed in concrete bases.

E. 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.

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches clearance from combustibles.

F. 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.

G. Copper and galvanized steel shall not be used in the fuel-oil piping system.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.

B. Connect engine exhaust pipe to engine with flexible connector.

C. Ground equipment according to NEC.

D. Connect wiring according to NEC. Provide a minimum of one 90-degree bend in flexible conduit routed to the generator set from a stationary element.

E. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to owner requirements.

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 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.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

a. Visual and Mechanical Inspection

1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.

4) Verify the unit is clean.

b. Electrical and Mechanical Tests

1) Perform insulation-resistance tests in accordance with IEEE 43.

a) Machines larger than 200 horsepower. Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 horsepower or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Conduct performance test in accordance with NFPA 110.
6) Verify correct functioning of the governor and regulator.

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. 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.
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 at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

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

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

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. 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.

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 26 43 13

TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS (SPD)

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 SPDs for low-voltage power, control, and communication equipment.

B. Related Sections include the following:
   1. Division 26 Section "Wiring Devices" for devices with integral SPDs.
   2. Division 26 Section "Switchboards" for factory-installed SPDs.
   3. Division 26 Section "Panelboards" for factory-installed SPDs.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. SVR: Suppressed voltage rating.

C. SPD: Transient voltage surge suppressor (known now as SPD.)

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 3rd edition.

C. Qualification Data:
   1. Per the requirements of NEC Article 285.6, provide test data demonstrating that the SPD is capable of surviving the published and specified short circuit current capability (AIC rating) without the use of external fusing.
   2. Provide a COMPLETE set of test and ratings data per the recommendations of NEMA LS1 – 1992.

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. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

B. 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."

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 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."

E. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."

F. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.6 PROJECT CONDITIONS

A. 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.

B. Placing into Service: Do not energize or connect service entrance equipment, panelboard, control terminals, data terminals, to their sources until the surge protective devices are installed and connected.

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. General 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 Substantial Completion.

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. Liebert Corporation; a division of Emerson.
   2. Advanced Protection Technologies, Inc.
   3. Current Technology, Inc.
   4. Cutler-Hammer, Inc.; Eaton Corporation.
   5. Intermatic, Inc.
   6. LEA International.
   7. Square D; Schneider Electric.
   8. APT: Advanced Protection Technologies

B. Manufacturers of Category A and Telephone/Data Line Suppressors:
   1. EDCO
   2. NTE Electronics, Inc.
   3. Telebyte Technology, Inc.

2.2 SERVICE ENTRANCE SUPPRESSORS

A. Surge Protection Device Description: Non-modular type from the following list of approved manufacturers and products provided the product meets all requirements of these Specifications. The SPD will be provided with the following features and accessories:
   1. 1. Repetitive Rating: SPD shall be capable of surviving at least 10,000 ANSI/IEEE C62.41 Category C3 impulses (10kA) without failure or less than 10% degradation of original performance characteristics.
   2. Fusing system to provide 200kAIC short circuit rating.
      The IEEE Emerald Book (IEEE Std. 1100 – 2005). Paragraph 9L1.3.1 states the following, “Component level fusing in a SPD can provide a fail-safe system preventing catastrophic failure or complete loss of protection.” Each of the manufacturers listed in this specification will provide independent fusing for each MOV in accordance with paragraph 3. below.
   3. Individually fused MOVs to provide system redundancy

IEEE Emerald Book (IEEE Std. 1100 – 2005). Paragraph 8.4.2.5 states the following, "…Surge protective device considerations: "…It is recommended practice that all SPDs have a means to disconnect them from service. Locating the SPD external to the switchboard or panelboard allows a disconnecting means to be located inside the switchboard or panelboard and does not require access to the switchboard or panelboard interior when servicing the SPD." Eliminate paragraph 4. below when the recommended breaker is provided in the distribution equipment.

4. Integral disconnect (only when a breaker is NOT provided in distribution equipment)
5. LED indicator lights for power and protection status.
6. Audible alarm, with silencing switch, to indicate when protection has failed.
7. One set of dry contacts rated at 5A and 250V ac, for remote monitoring of protection status.
8. NEMA 12 Enclosure.

B. Surge Protection Device Description: Modular type from the following list of approved manufacturers and products provided the product meets all requirements of these Specifications:
1. Liebert Corporation – Interceptor II Series
2. Current Technology, Inc. – SEL Series
3. Cutler-Hammer – CPS Series

The modular SPD will be provided with the following features and accessories:
1. Repetitive Rating: SPD shall be capable of surviving at least 15,000 ANSI/IEEE C62.41 Category C3 impulses (10kA) without failure or less than 10% degradation of original performance characteristics.
2. Fusing system to provide 200kAIC short circuit rating.
3. Fabrication using bolted compression lugs for internal wiring.
5. Individually fused MOVs to provide system redundancy.
6. Built-in push-to-test feature that tests the integrity of each fuse/MOV pair. Manufacturers who accomplish by use of an external surge generator will provide the device with their quotation.
7. Redundant replaceable modules
8. Arrangement with copper bus bars and for bolted connection to phase buses, neutral bus, and ground bus.
9. Arrangement with wire connection to phase buses, neutral bus, and ground bus.
10. LED indicator lights for power and protection status.
11. Audible alarm, with silencing switch, to indicate when protection has failed.
12. One set of dry contacts rated at 5A and 250V ac, for remote monitoring of protection status.
13. Surge event operations counter.
14. NEMA 4 Enclosure

C. Peak Single-Impulse Surge Current Rating: 200kA per mode. Manufacturer will provide a higher maximum surge current rating if necessary to meet the repetitive requirements listed above.Connection Means:

D. Connection Means: Permanently wired.

E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 480Y/277, 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120 and 700V for 480Y/277V.
2. Line to Ground: 400 V for 208Y/120 and 700V for 480Y/277V.
3. Neutral to Ground: 400 V for 208Y/120 and 700V for 480Y/277V.

F. Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
   1. Line to Neutral: 400 V.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

G. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
   1. Line to Neutral: 400 V, 800 V from high leg.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

H. Protection modes and UL 1449 SVR for voltages of 240, 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
   1. Line to Line: 2000V for 480V, 1000V for 240V, 2500V for 600V.
   2. Line to Ground: 2000V for 480V, 1000V for 240V, 2500V for 600V,
   3. 2.3 PANELBOARD SUPPRESSORS

I. 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.

J. Surge Protection Device Description: Modular design with field-replaceable modules, sign-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.

K. Peak Single-Impulse Surge Current Rating: 100kA per mode.

L. 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.

M. Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
   1. Line to Neutral: 400 V.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

N. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
   1. Line to Neutral: 400 V, 800 V from high leg.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

O. Protection modes and UL 1449 SVR for voltages of 240, 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
   1. Line to Line: 1000 V for 240 V.
   2. Line to Ground: 800 V for 240 V.

2.3 SUPPRESSORS FOR BRANCH PANELS

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.
   5. Fusing system to provide 200kAIC short circuit rating.
   6. Repetitive Rating: SPD shall be capable of surviving at least 6,000 ANSI/IEEE C62.41 Category C3 impulses (10kA) without failure or less than 10% degradation of original performance characteristics.
   7. NEMA 4X Enclosure
   8.

B. Peak Single-Impulse Surge Current Ratings; 130 kA per phase, 65kA per mode. Manufacturer will provide a higher maximum surge current rating if necessary to meet the repetitive requirements listed above.

C. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 480Y/277 208Y/120, 600Y/347, 4-wire circuits shall be as follows:
   1. Line to Neutral: 800 for 480Y/277, 400V for 208Y/120, 1200V for 600Y/347.
   2. Line to Ground: 800V for 480Y/277, 400V for 208Y/120, 1200V for 600Y/347.
   3. Neutral to Ground: 800V for 480Y/277, 400V for 208Y/120, 1200V for 600Y/347.

D. Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
   1. Line to Neutral: 400 V.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

E. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
   1. Line to Neutral: 400 V, 800 V from high leg.
   2. Line to Ground: 400 V.
   3. Neutral to Ground: 400 V.

F. Protection modes and UL 1449 SVR for voltages of 240, 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
   1. Line to Line: Line to Line: 2000V for 480V, 1000V for 240V, 2500V for 600V.

2. Line to Ground: 2000V for 480V,1000V for 240V, 2500V for 600V.

2.4 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.

2.5 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. Locate the externally mounted SPD as close as possible to the panelboard neutral lug. Locate the recommended breaker as close as possible to the SPD location. The panelboard manufacturer will supply the breaker. Do not exceed manufacturer’s recommended lead length. Do not bond neutral and ground.

C. Provide a 60A, multi-pole circuit breaker in the service entrance equipment and a 30A, multi-pole circuit breaker in branch panel equipment to serve as a dedicated disconnect for suppressor, unless otherwise indicated.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 PLACING SYSTEM INTO SERVICE

A. Do not energize or connect panelboards to their sources until surge protection devices are installed and connected.

3.4 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.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.

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

3.5 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."

B. Train Owner’s maintenance personnel on procedures and schedules for maintaining suppressors.

C. Review data in maintenance manuals. Refer to Division 1 Section “Contract Closeout.”

D. Review data in maintenance manuals. Refer to Division 1 Section “Operation and Maintenance Data.”

E. Schedule training with Owner, through Architect, with at least seven days’ advanced notice.

END OF SECTION

SECTION 26 51 16 - LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Luminaire supports.

B. Related Requirements:

1. Section 26 09 23"Lighting Control Devices" for automatic control of lighting, including occupancy sensors, and multipole lighting relays and contactors.

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. 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, 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. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

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 ballast for bi-level and dimmer-controlled luminaires, from manufacturer.

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.

1. Warranty Period: Two year(s) from date of Substantial Completion.

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 LED 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 minimum 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. Nominal Operating Voltage: See Light Fixture Schedule on Plans.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

2.3 LED EXTERIOR 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. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.6.

F. CRI of minimum 80. CCT of 4000 K.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Nominal Operating Voltage: See Light Fixture Schedule on plans.

J. In-line Fusing: Separate in-line fuse for each luminaire.

K. Lamp Rating: Lamp marked for outdoor use.

L. Source Limitations: Obtain luminaires from single source from a single manufacturer.

M. 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.

N. 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.

O. 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.

2.4 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.

C. Diffusers and Globes:

1. Clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

2.5 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.

2.6 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.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.

C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gauge.

D. Rod Hangers: 3/16-inch 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. Remote Mounting of Ballasts: Distance between the ballast and luminaire shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

C. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

D. Install lamps in each luminaire.

E. Supports: Sized and rated for luminaire weight.

F. Ceiling-Grid-Mounted Luminaire Supports:

1. Install ceiling support system rods or wire for each luminaire. Locate not more than 6 inches from luminaire corners.
2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires 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 luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.

G. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

H. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

I. 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 wire support 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.

J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 05 33 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

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.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 27 53 19

EMERGENCY RESPONDER RADIO ANTENNA/REPEATER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, install, and test a complete and operating Emergency Responder Radio Antenna/Repeater System.

1.2 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.

1.3 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.

1.4 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 were 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

1.5 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.

1.6 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 Frequency	Upstream/ Mobile-to-base Frequency	Channel 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 700 - 800 MHz 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 Electrical Room. 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.
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 Electrical Room. If additional power is required at this or other locations such must be clearly specified as part of the submitted system design.
2. A secondary automatic transfer power source for all active electronic components in the system shall be provided. Supplier shall provide battery backup for 5 minutes of operation. System backup is by generator; however, battery back shall be provided for momentary losses. If a generator is provided, battery backup capacity shall be 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.

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.

I. Compatibility
The system shall not cause harmful interference to other RF systems in the building.

J. RF Exposure
The system shall meet the RF exposure guidelines of FCC Bulletin OET 65.

1.7 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.
   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.

1.8 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
   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.

1.9 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

2.1 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

2.2 SYSTEM COMPONENTS

A. Donor Antennas

1. Electrical:
   a. Frequency band: 700-900 MHz covering the frequencies specified by the AHJ.
   b. VSWR ≤ 1.5:1
   c. Gain: ≥ 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°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 ½” 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 ≤ 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°C
    b. Plenum rated

C. Directional Coverage Antennas
1. Electrical
    a. Frequency band: 698-900 MHz
    b. VSWR ≤ 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°C
b. Plenum rated

D. Radiating Cable
1. Material:
a. Nominal size: ½” or 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: 50Ω ± 1
3. Environmental:
4. Temperature: -20°C to +80°C

E. Foam Dielectric Cable
1. Material:
a. Nominal size: ½” or 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: 50Ω ± 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 ≤ 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 Cabarrus 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, DEFINATIONS for descriptions of each DAQ level.
    a. Each floor of the building shall be divided into a grid of approximately 40 equal areas.
    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 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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 SCOPE

A. This standard provides the functional requirements for the installation, programming, configuration, warranty and maintenance of a complete Class B Analog/Addressable Intelligent Fire Alarm / Life Safety System.

B. This Fire Alarm / Life Safety System Standard must be conformed to in its entirety to ensure that the installed and programmed Life Safety System will function as designed and will accommodate the future requirements and operations required by the building owner. All specified operational features will be met without exception.

C. Section Includes:

1. Fire-alarm control unit
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Standby Power Supplies.
8. Device guards.
9. Magnetic door holders.
10. Remote annunciator.
11. Addressable interface device.
12. Digital alarm communicator transmitter.
13. Surge Protection and Grounding.
14. CO Detector.
15. Programming, Commissioning and Training of Operators.
16. Conduit, wire and accessories required to furnish a complete and Operational Life Safety System.

D. Related Requirements:

1. Section 28 05 13 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. NICET: National Institute for Certification in Engineering Technologies.

1.4 PERFORMANCE REQUIREMENTS

A. Statutory and Reference Standard Compliance:

1. The latest edition of the North Carolina State Building Code.
2. North Carolina Department of Insurance "Requirements for Fire Alarm Detection and Alarm Systems", latest revision.
3. National Fire Protection Association Standards:

    a. NFPA 70 - National Electric Code
    b. NFPA 72 - National Fire Alarm Code
    c. NFPA 90A - Air Conditioning Systems
    d. NFPA 101 - Life Safety Code

4. Underwriters Laboratories Inc. for use in fire protective signaling systems shall list the system and all components. The UL Label shall be considered as evidence of compliance with this requirement. The equipment shall be listed by UL under the following standards as applicable:

    a. UL 864/UOJZ, APOU - Control Units for Fire Protective Signaling Systems.
    b. UL 1076/APOU - Proprietary Burglar Alarm Units and Systems.
    c. UL 268 - Smoke Detectors for Fire Protective Signaling Systems.
    d. UL 268A - Smoke Detectors for Duct Applications.
    e. UL 217 - Smoke Detectors Single Station.
    f. UL 521 - Heat Detectors for Fire Protective Signaling Systems.
    g. UL 228 - Door Holders for Fire Protective Signaling Systems.
    h. UL 464 - Audible Signaling Appliances.
    i. UL 1638 - Visual Signaling Appliances.
    j. UL 38 - Manually Activated Signaling Boxes.
    k. UL 346 - Water flow Indicators for Fire Protective Signaling Systems.
    l. UL 1971 - Visual Signaling Appliances.
    m. UL 1481 - Power Supplies for Fire Protective Signaling Systems.

5. Americans with Disabilities Act (ADA).

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.

7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.
    d. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, 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.

C. Field quality-control reports.

1.7 SAMPLE WARRANTY: FOR SPECIAL WARRANTY.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

B. REVIT and AUTOCAD copy of the as-built fire alarm map (not just the system as-builts). This is the as-built map that is posted by the annunciator.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

C. 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.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: The installer shall be a licensed low voltage contractor and a factory authorized distributor to ensure proper specification adherence, final connection, test, turnover, warranty compliance and service. The installer shall maintain a service organization with adequate spare parts stock within 50 miles of the installation. Installer shall have training certification by the manufacturer of the Fire Alarm Control Equipment. This certification shall not be more than two years old, to ensure up-to-date product and application knowledge on the part of the installing installer.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level IV technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. 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 Architect and Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Architect's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Two years from date of Substantial Completion.

B. Installer Warranty: Installer shall warrant the installed fire alarm system to be free from any defects of material and installation for a period of 2 years from acceptance by the professional engineer and/or owner.

1. Any deficiencies shall be immediately corrected at no additional cost to the owner.
2. Any defects that render the system inoperative shall be repaired within 24 hours of the owner notifying the contractor. Other defects shall be repaired within 48 hours of the owner notifying the contractor.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment furnished for this project shall be new and unused. All equipment, materials, accessories, devices, and other facilities covered by this guideline or noted on contract drawings and installation specifications shall be the best suited for the intended use and shall be provided by a single manufacturer.

B. Manufacturer's representative and a Record of Completion presented upon completion shall verify system installation and operations. The manufacturer's representative shall be responsible for an on-site demonstration of the operation of the system and initial staff training.

2.2 SYSTEM DESCRIPTION

A. All Control Panel Assemblies and the connected Automatic and Manual Alarm and Notification Appliances shall be designed and manufactured by the same company, shall be tested and cross-listed as compatible (to category UOJZ) to ensure that a fully functioning Life Safety System is designed and provided.

B. The Fire Alarm / Life Safety System supplied under this guideline shall be a microprocessor-based direct wired system. System shall utilize independently addressed, microprocessor-based smoke detectors, heat detectors, and modules, as described in this specification.

C. All initiation devices shall be analog addressable devices. The notification devices shall be installed where required to meet ADA, NFPA 72 and Charlotte- Mecklenburg Building Standards codes.

D. Locate the Fire Alarm Panel in the main electrical room. Locate a full function annunciator in the main office and a display only alpha-numeric display at the front door.

E. All Fire Alarm / Life Safety equipment shall be arranged and programmed to provide an integrated system for the early detection of fire, the notification of building occupants, the override of the HVAC system operation, the shut-down of the kitchen hood, and the activation of other auxiliary systems to inhibit the spread of smoke and fire and to facilitate the safe evacuation of building occupants.

F. All strobes shall be synchronized. A strobe unit shall be installed in every occupied space which includes all classrooms, restrooms, conference rooms, tutor rooms, science prep rooms and waiting areas/lobbies. Smoke and thermal detectors shall be installed in compliance with NFPA 72 codes. Duct detectors shall interface with HVAC systems to shut down necessary air-handling units.

G. The fire alarm system shall be microprocessor driven with stored program controllers. Each panel (node) on the network shall use a multiple microprocessor design so that the failure of a single microprocessor will not result in a local failure. Fire alarm systems that utilize only one microprocessor for system (node) and SLC control will not be accepted.

H. The Life Safety System shall be UL listed under Standard 864 (Control Units for Fire-Protective Signaling Systems) under categories UOJZ and APOU. The specified modules shall also be listed under UL 1076 (Proprietary Burglar Alarm Units and Systems) under category APOU.

I. A standby power supply shall automatically supply electrical energy to the system upon primary power supply failure. Use “Emergency Generator” circuit where available. Standby power shall be an electrical battery with capacity to operate the system under maximum supervisory load for 24 hours and capable of operating the system for 5 minutes in the alarm mode at 100% load. Fire alarm shall include a charging circuit to automatically maintain the electrical charge of the battery.

J. Do not install notification appliances on the exterior of the building unless specifically directed to do so by the Project Manager.

K. Remote LED indicators must be installed at each duct detector location. Install the indicator in the ceiling so it can be seen while standing in the corridor/classroom.

L. All power supplies must be on dedicated circuits. Existing building circuits (receptacles, lights, etc.) cannot be used. Use generator power where available.

M. Smoke detectors shall be installed a minimum of 3’ from air supply diffusers and lighting fixtures.

N. Automatic door closers to be activated by local smoke detectors only.

O. Use toggle bolts for all wall mounted equipment/components/appliances

P. All Fire Alarm wiring shall be FPLR or FPLP in conduit or duct, or MC fire alarm cable.

Q. Provide remote LED indicator lights for all duct detectors. Locate indicators in corridors.

R. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

S. Automatic sensitivity control of certain smoke detectors.

T. All components provided shall be listed for use with the selected system.

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

2.3 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. Fire-extinguishing system operation.
7. Fire standpipe system.
8. Fire pump running.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Local sounding device at panel shall be activated.
3. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
4. Transmit an alarm signal to the remote alarm receiving station.
5. Unlock electric door locks in designated egress paths.
6. Release fire and smoke doors held open by magnetic door holders.
7. Activate voice/alarm communication system.
8. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
10. Recall elevators to primary or alternate recall floors.
11. Activate emergency shutoffs for gas and fuel supplies.
12. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Alert and Action signals of air-sampling detector system.
3. Elevator shunt-trip supervision.
4. User disabling of zones or individual devices.
5. Loss of communication with any panel on the network.
6. Carbon monoxide detectors.
7. Fire pump running.
8. Fire-pump loss of power.
9. Fire-pump power phase reversal.
10.

D. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
2. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
3. Display system status on graphic annunciator.
4. Transmit an alarm signal to the remote alarm receiving station.

E. 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 communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.

F. System Trouble Signal Actions:

1. Trouble indicator shall flash.
2. A local sounding device in the panel shall be activated
3. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
4. Unacknowledged alarm messages shall have priority over trouble messages, and if such an alarm must also be displayed, the trouble message will not be displayed until the operator has acknowledged all alarm messages.
5. Transmit an alarm signal to the remote alarm receiving station.

2.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.5 FIRE-ALARM CONTROL UNIT

A. Basis-of-Design Product: New fire alarm system components shall match existing system manufacturer.

B. The above constitute the minimum type and quality of equipment to be installed.

1. Loop Controller Interface:

   a. An Electronic 100% digital Loop Controller shall be provided in each Fire Alarm Control Panel (where needed), to interface between the panel and the Analytical Microprocessor-based Detectors and modules.
   b. It shall be possible to connect the electronic loop controller to the Analytical Microprocessor-based Detectors and modules utilizing any wiring material or method complying with Chapter 3 of the National Electrical Code (ANSI/NFPA 70-1996) as Class A (Style 6 or Style 7) or Class B (Style 4) circuits without the use of special shielding, twisted wire, or conduits. It must be possible to wire branch circuits (T-Taps) from Class B Circuits (Style 4). Each Electronic Protection Loop shall be configurable to operate as a Style 7 loop without the need for additional hardware modules.
   c. All system programming and history shall be permanently stored in non-volatile memory to ensure that no programming or history is lost. Systems which store initial programming or field programming changes in battery backed memory will not be accepted.
   d. The Electronic Loop Controller shall be capable of setting the address of all Analytical Microprocessor-based Detectors and modules connected to it electronically, without the need to set switches at any of the individual devices.
   e. The Electronic Loop Controller shall notify the System Operator when any connected smoke detector reports a “Routine Maintenance Required” signal to the system.

2. Notification Appliance Circuits:

   a. Provide where indicated on the plans supervised hard-wired Notification Appliance Circuits (NAC) for the control of 24VDC signaling appliances. Each NAC shall operate as a Class B (Style Y) circuit and shall be capable of controlling up to 3.5 amps of signaling power.

b. NAC's shall be power limited to 3.5A at 24VDC and 4.1A at 20.4VDC to support higher current demand by visible appliances at lower battery voltages.

3. Remote Diagnostic Utility - RDUEU-E or equal:

a. The Fire Alarm System shall have the ability to report its status and sensitivity remotely over dial-up modem to a personal computer. The system shall be capable of generating sensitivity, system status, and trend analysis reports from data downloaded from the panel. Installer to provide the modem at the panel.

2.6 MANUAL FIRE-ALARM BOXES

A. The Microprocessor-based Addressable Fire Alarm Stations shall be a Lexan double action fire alarm stations and fit in to a standard electrical box

B. Stations shall be key reset.

C. Station shall be in red with white "PULL IN CASE OF FIRE" lettering.

2.7 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. System shall use Analytical Microprocessor-based Detectors that are capable of full digital communications with the Fire Alarm / Life Safety System using both broadcast and polling communications protocols. Each detector shall be capable of performing independent advanced fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted nuisance alarms caused by environmental events. Signal patterns that are not typical of fires shall be eliminated by digital filters and will not cause a system alarm condition. Devices not capable of combining different fire parameters or employing digital filters will not be acceptable.
2. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detectors' memory. Detectors not capable of making independent alarm decisions are not be acceptable. Maximum total loop response time for detectors changing state (alarm or trouble) shall be 0.5 seconds.
3. Each detector shall be capable of identifying diagnostic codes to be used for system maintenance. All diagnostic codes shall be stored in the detector. Each smoke detector shall be capable of transmitting pre-alarm, alarm, and maintenance signals to the Fire Alarm Control Panel via the Electronic Loop Controller.
4. All of these devices and their bases will also be required to be labeled with engraved Lexan labels to identify device address and intended location. Labels shall be red background with white letters, letters shall be a minimum of 1/4" in height.

B. Photoelectric Smoke Detectors:

1. Photoelectric detector shall utilize a light scattering type photoelectric smoke sensor to detect visible particulates produced by combustion. The integral microprocessor shall dynamically examine values from the sensor and initiate a system alarm based on the analysis of data. Detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. Information shall be stored in the detectors' memory and shall be transferred to the electronic loop

controller for retrieval using a laptop PC or the Intelligent Detector Program/Service Tool designed by the manufacturer specifically for the purpose.

2. The alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5% smoke obscuration per foot. The photo detector shall be suitable for operation in the following environment:

   a. Temperature: 32º F to 120º F (0oC to 49oC)
   b. Humidity: 0-93% RH, non-condensing
   c. Elevation: no limit

2.8 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. System shall use Analytical Microprocessor-based Detectors that are capable of full digital communications with the Fire Alarm / Life Safety System using both broadcast and polling communications protocols. Each detector shall be capable of performing independent advanced fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted nuisance alarms caused by environmental events. Signal patterns that are not typical of fires shall be eliminated by digital filters and will not cause a system alarm condition. Devices not capable of combining different fire parameters or employing digital filters will not be acceptable.
2. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detectors' memory. Detectors not capable of making independent alarm decisions are not be acceptable. Maximum total loop response time for detectors changing state (alarm or trouble) shall be 0.5 seconds.
3. Each detector shall be capable of identifying diagnostic codes to be used for system maintenance. All diagnostic codes shall be stored in the detector. Each smoke detector shall be capable of transmitting pre-alarm, alarm, and maintenance signals to the Fire Alarm Control Panel via the Electronic Loop Controller.
4. All of these devices and their bases will also be required to be labeled with engraved Lexan labels to identify device address and intended location. Labels shall be red background with white letters, letters shall be a minimum of 1/4" in height.

B. Detectors - Fixed Temperature/Rate of Rise Heat Detector:

1. Heat Detector shall have a solid-state heat sensor, and shall transmit an alarm at a fixed temperature of 135º F (57ºC) or due to a temperature Rate of Rise of 15ºF/minute (9ºC/minute). The detector shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm.
2. The heat detector shall be rated for ceiling installation at 70 ft (21.3m) centers and be suitable for wall mount applications.
3. Heat detectors provided for kiln rooms shall be standard rated.

2.9 DETECTOR MOUNTING BASES

A. Mounting base will not contain any electronics, shall support all Microprocessor-based Smoke detector types detailed in this specification, and have the following minimum requirements:

1. Removal of the respective detector will not affect electronic loop communications with other detectors on that loop.

2. Field Wiring Connections shall be made to the room side of the base, so that wiring connections can be made or disconnected by the installer without the need to remove the mounting base from the electrical box.
3. The base shall be capable of supporting remote alarm annunciation.
4. Bases will have the option of external L.E.D. operation, Relay base or data line isolator base.

   a. Relay base shall mount in a standard electrical box described above and provide Form “C” contacts rated at 1 amp @ 30VDC and listed for “pilot duty”.
   b. Isolator bases shall operate within a minimum of 23 msec. Of a short circuit on the data line, shall run self-test procedure to re-establish normal operation, and shall operate in a class ‘A’ operation as well as class ‘B’.

2.10 DUCT DETECTOR HOUSING

A. The Analytical Microprocessor-based photoelectric smoke detector shall be readily adaptable for use in air duct smoke detection applications, using a housing that mounts to the outside of the duct. When used for duct smoke detection, the smoke detectors will not forfeit any of the system functionality which they have when used as area smoke detectors.

B. The duct smoke detection housing shall allow the detector to sample and compensate for, variations in duct air velocity between 300 and 4000 feet per minute.

C. Remote alarm LEDs and Remote Test Stations shall be supported by the duct smoke detector and provided where indicated.

D. All detectors used in duct applications shall be located in accordance with NFPA 72 recommendations.

2.11 NOTIFICATION APPLIANCES

A. General:

1. All appliances which are supplied for the requirements of this specification shall be U.L. Listed for Fire Protective Service and shall be capable of providing the “Equivalent Facilitation” which is allowed under the Americans with Disabilities Act Accessibilities Guidelines (ADA (AG)), and shall be UL 1971, and ULC S526 Listed.
2. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel specified to insure absolute compatibility between the appliances and the control panels, and to ensure that the application of the appliances are done in accordance with the single manufacturers’ instructions.
3. All horns shall be electronic, with field selectable jumpers to set operation for either continuous ring or temporal pattern and shall provide an adjustable high output or low output at 98dB or 94dB. In - Out screw terminals shall be provided for wiring, the use of ‘pig-tail’ type connectors are not acceptable.
4. Wall or ceiling mount notification devices are acceptable.
5. All speaker/strobes shall have selectable candela output and wattage switch.
6. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
7. Matching Transformers: Tap range matched to acoustical environment of speaker location.

B. Self - Synchronized Strobes:

1. Strobes shall be supplied by the same manufacturer as the Fire Alarm Control Equipment. In - Out screw terminals shall be provided for wiring. The Strobes shall have a red or white plastic faceplate. They shall provide the proper candela output for the project per NFPA 72 spacing guidelines and synchronized flash outputs minimum requirements. The strobe shall have lens markings oriented for wall mounting.
2. In - Out screw terminals shall be provided for wiring. They shall provide synchronized flash outputs as required to comply with code requirements.

2.12 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require 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.

2.13 REMOTE ANNUNCIATOR

A. Remote LCD annunciators shall have the full ability and duplicate in all fashion the main user interface located on the control panel. This includes the ability to control all system functions, tests, programming, and annunciations.

B. Annunciator shall also include the ability to add programmable switches and or LED’s as required for special functions without the need to add additional wires or cabinets.

C. Locate one remote full function LCD annunciator in the administration area of the building.

D. Locate one display only alpha-numeric annunciator adjacent to the front door.

2.14 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Fire Alarm / Life Safety System shall incorporate microprocessor-based addressable modules for the monitoring and control of system Input and Output functions over a 2 wire electronic communications loop, using both broadcast and serial polling protocols. All modules shall display communications and alarm status via LED indicators.
2. The function of each connected module shall be determined by the module type, and shall be defined in the system software through the application of a personality code. Simply changing the associated personality code may change module operation at any time.
3. All addressing of the Microprocessor-based Addressable Modules shall be done electronically, and the electrical location of each module shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the modules will not be dependent on their electrical location on the circuit.
4. All field wiring to the Microprocessor-based Addressable Modules shall be supervised for opens and ground faults and shall be location annunciated to the module of incidence.

5. Diagnostic circuitry, and their associated indicators, with reviewable Trouble Codes, shall be integral to the Microprocessor-based Addressable Modules to assist in troubleshooting system faults.
6. The module shall be suitable for operation in the following environment:

    a. Temperature: 32oF to 120oF (0oC to 49oC)
    b. Humidity: 0-93% RH, non-condensing

B. Single Input Module:

1. Microprocessor-based Addressable Modules shall be used to provide one (1) supervised Class B (style B) input circuit capable of latching operation for use with contact devices, non-damped water flow switches, non-latching supervisory sprinkler switches.

C. Dual Input Module:

1. Microprocessor-based Addressable Modules shall be used to provide two (2) independent supervised Class B (style B) input circuits capable of operating with two (2) contact devices. Both of the input circuits shall be terminated to, and operated from, the same microprocessor-based addressable module. The Initiating Device Circuit connected to the module shall be fully supervised for open circuits and ground faults.

D. Single Riser Signal Module:

1. The Microprocessor-based Addressable Single Input Signal Module shall provide one (1) supervised Class B (style Y) Notification Appliance Circuit capable of a controlling 2A of polarized 24 VDC Notification Appliances, 50W speaker circuit power @ 25VRMS, or 35W speaker circuit power @ 70VRMS.

E. Control Relay Module:

1. Microprocessor-based Addressable Control Relay Modules shall provide one form "C" dry relay contact rated at 2 amps @ 24 VDC or 0.5 amps at 120 VAC to, control external appliances or equipment processes. The control relay module shall be rated for pilot duty applications and releasing systems service. The position of the relay contact shall be confirmed by the system firmware.

2.15 FIRE PULL STATION SIGNAGE

A. Description: The signs shall read "FIRE PULL STATION". Signs shall be 3"x 8" x.0.13" made of molded styrene. White 0.132" raised copy letters with red background and Braille Grade 2. Letters to be ¾" high, Helvetica medium and all caps.

2.16 MAPS

A. Description: Provide updated map showing all initiating devices and their address numbers.

2.17 SURGE PROTECTION

A. AC Protection provide Surge Suppression Incorporated Model S-SPT120-15 or equal.

B. Notification Appliance Circuit (NAC) Protection provide Surge Suppression Incorporated Models TC24D2-B, TP224D4-B, or TP224D8-B or equal.

C. Initiating Device Circuit (IDC) Protection provide Surge Suppression Incorporated Models DP24C2-B, DC24C2-B, TC24D2-B, TP224D4-B, or TP224D8-B or equal.

D. Signaling Line Circuit (SLC) Protection provide Surge Suppression Incorporated Models DP24C2-B, DC24C2-B, TC24D2-B, TP224D4-B, or TP224D8-B or equal.

E. Auto Dialer Lines Protection provide Surge Suppression Incorporated Models TC130D2-B, TC130D4-B, or TC130D6-B or equal.

F. Point of Use AC Protection provide Surge Protection Incorporated Model S-SPIU2 or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. The entire system shall be installed in a workmanlike manner in accordance with approved manufacturers manuals and wiring diagrams. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation.

1. All wiring shall be of the type recommended by the NEC, approved by local authorities having jurisdiction for the purpose, and shall be installed in dedicated raceways throughout. All wiring shall be in conduit or the special MC cable noted below. Wiring shall be in rigid conduit when run outside above ground and in PVC when run outside below ground. Wiring run below ground shall be suitable for wet locations. Wiring shall be color coded red. All wiring shall be installed by the low voltage installer. All final connections shall be made by the low voltage installer.
2. Run all fire alarm cable in separate pathways from other low voltage circuits.
3. For indoor use, an acceptable alternative to cable in rigid conduit in most locations will be plenum rated MC fire alarm/control cable equal to AFC Cable Systems type FPLP.

Cable will be color coded red. In new construction, EMT will be run in walls to a surface mounted box above the ceiling. MC cable will be run to the box with the armor stripped off enough to feed the device connected to the conduit without using additional splices. Use separate cables for data and signals. Where not run in cable trays, cable will be supported in a similar manner as conduit. The fire alarm installer will be responsible for the installation of the fire alarm MC cable and fire alarm devices. The electrical contractor will provide AC power and conduit stub-ups in walls and related boxes. Connectors used will be those designed specifically for this type of cable.

4. All junction and connection boxes shall be painted red for easy identification.
5. All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes.
6. End of Line Resistors: Shall be furnished as required for mounting as directed by the manufacturer.
7. All wiring and equipment shall be installed according to the NEC and North Carolina Building Codes per the drawings submitted by the authorized Engineered Systems Distributor.
8. Field Connected Devices must be installed and wired by a Factory Trained and Authorized Fire Alarm Installer or a licensed electrical contractor under direct supervision of a Factory Trained and Authorized Fire Alarm Installer.
9. All auxiliary Power Supplies or other Fire Panels shall be located in electrical or mechanical rooms. They shall be mounted at a height between 48 to 60 inches from floor level. All such panels shall be “supervised” by the main Fire Alarm Panel.

C. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing [control] [monitoring] equipment as necessary to extend existing [control] [monitoring] functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
4. Install ADA compliant Stopper II pull station covers with alarm signal over all pull stations.
5. Install identification signs next to all pull stations. Mount signs securely with screws or liquid nails. The center point of the signs shall correspond with the center point of the pull stations.

F. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

G. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

I. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

J. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

K. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

L. Audible/Visible or Visible Only Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

1. Protective covers shall be placed over the horn / strobe units in the Gym and Multi - Purpose room.

M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 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 Section 08 71 00 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Magnetically held-open doors.
2. Electronically locked doors and access gates.
3. Alarm-initiating connection to elevator recall system and components.
4. Alarm-initiating connection to activate emergency lighting control.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at elevator shunt-trip breaker.
7. Data communication circuits for connection to building management system.
8. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
9. Supervisory connections at fire-pump engine control panel.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

C. Install identification map showing all initiating devices and their address numbers beside the main panel for quick and easy location of alarmed or troubled devices.

1. Map shall be mounted under glass.

3.5 SURGE PROTECTION AND GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

C. All equipment shall be properly grounded. Main panel shall be grounded directly to ‘earth ground’.

D. Surge protection shall be installed on the AC supply circuit at the Fire Alarm Panel and on all initiating, notification and monitoring circuits at the Fire Alarm Panel. In addition, surge protection shall be installed on all initiating, notification and monitoring circuits at all points of entry to a building from the outside.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

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 the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
b. Comply with the "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 the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the private operating mode according to manufacturer's written instructions.
4. Test visible appliances for the public operating mode according to manufacturer's written instructions.
5. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.9 COMMISSIONING

A. The system shall be commissioned in accordance with the needs of the occupants of the protected building. Both “Complete System Commissioning” and “Phased System Commissioning” shall be possible with the specified system, and the execution of either method of commissioning shall be treated as stand-alone projects, and shall be documented as such, including the need for a complete contract close out submittal package for each Project Phase.

B. Complete System Commissioning:

1. The Factory Trained and Authorized Fire Alarm Installer in the presence of the Local AHJ, the Building Owners’ Representative, and a Representative of the General Contractor shall perform commissioning of the entire installed system, if deemed appropriate.
2. A complete system documentation package shall be provided to the Local Authority Having Jurisdiction and the Building Owners’ Representative at the time of commissioning.

3.10 DEMONSTRATION

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

1. The Fire Alarm Installer shall schedule and execute an instruction class for the Building owner, which details the proper operation of the installed fire alarm system. The instruction shall also cover the schedule of maintenance required by NFPA 72 and any additional maintenance recommended by the system manufacturer.
2. This instruction shall also be separately furnished to the Local Municipal Fire Department if so requested by the Local Authority Having Jurisdiction.
3. The instruction shall be a minimum of 8 hours in duration and presented in an organized and professional manner by a person factory trained in the operation and maintenance of the equipment and who is also thoroughly familiar with the installation.
4. The Fire Alarm Installer shall provide service and operation manuals or any other curricula that may enhance the instruction of the Building Owners or Local Municipal Fire Department in the operation and maintenance of the system. Also provide software and hardware necessary to troubleshoot and completely program the system

B. The completely installed fire alarm system will be fully tested in compliance with Testing Procedures for Signaling Systems (ANSI/NFPA 72) under the supervision of a trained manufacturer’s representative. The system shall be demonstrated to perform all the functions as specified.

C. The Fire Alarm Installer shall test:

1. Every alarm initiating device for proper response and program execution.
2. Every notification appliance for proper operation and audible/visual output.
3. All auxiliary control functions such as elevator capture, smoke door and damper release, and functional override of HVAC, ventilation, and pressurization controls.

D. After the system has been completely tested to the satisfaction of the Project Manager, the Fire Alarm Installer shall complete the Fire Alarm System Certification of Completion form published by the NFPA (Figure 1-7.2.1 in the National Fire Alarm Code).

E. The completed form signed by a principal of the Fire Alarm System installer shall be delivered to the Project Manager with the other system documentation required by these specifications.

F. All installation inspections are required prior to the walk through with the Fire Marshal.

END OF SECTION

SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Product Data

Materials Other Than Salable Timber;

Written permission to dispose of such products on private property shall be filed with the Engineer.

Samples

Tree wound paint

Submit samples in cans with manufacturer's label.

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to, store at the site, and handle in a manner that will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 PRODUCTS

2.1 TREE WOUND PAINT

Bituminous based paint of standard manufacture specially formulated for tree wounds.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2 Trees, Shrubs, and Existing Facilities

Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Engineer immediately of damage to or an encounter with an unknown existing utility line. The Contractor shall be responsible for the repairs of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines, which are to be removed, are encountered within the area of operations, the Contractor shall notify the Engineer in ample time to minimize interruption of the service.

3.2 CLEARING

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing shall also include the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 1-1/2 inches or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 1-1/2 inches in diameter shall be painted with an approved tree-wound paint.

3.3 TREE REMOVAL

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Trees shall be disposed of as specified in paragraph DISPOSAL OF MATERIALS.

3.4 PRUNING

Prune trees designated to be left standing within the cleared areas of dead branches 1 1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1 1/4 inches in diameter with approved tree wound paint.

3.5 GRUBBING

Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.

3.6 DISPOSAL OF MATERIALS

3.6.1 Saleable Timber

All timber on the project site noted for clearing and grubbing shall become the property of the Contractor, and shall be removed from the project site and disposed of off stations.

3.6.2 Nonsaleable Materials

Logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations, except for salable timber, shall be disposed of by burning or other acceptable means at the Contractor’s descretion, except when otherwise directed in writing. Such directive will state the conditions covering the disposal of such products and will also state the areas in which they may be placed. Refuse to be burned shall be burned at specified locations and in a manner to prevent damage to existing structures and appurtenances, construction in progress, trees, and other vegetation. The Contractor shall be responsible for compliance with all Federal and State laws and regulations and with reasonable practice relative to the building of fires. Burning or other disposal of refuse and debris and any accidental loss or damage attendant thereto shall be the Contractor's responsibility.

-- End of Section --

SECTION 31 22 00

SITE EARTHWORK
09/00

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASPHALT INSTITUTE (AI)

AI MS-10	(1986) Soils Manual for Design of Asphalt Pavement Structures

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A227/A227M	(1993) Steel Wire, Cold-Drawn for Mechanical Springs
ASTM A229/A229M	(1993) Steel Wire, Oil-Tempered for Mechanical Springs
ASTM C14	(1995) Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C33	(1997) Concrete Aggregates
ASTM C136	(1996; Rev. A) Sieve Analysis of Fine and Coarse Aggregates
ASTM D422	(1963; R 1990) Particle-Size Analysis of Soils
ASTM D698	(1991) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft (600 kN-m/m))
ASTM D1140	(1997) Amount of Material in Soils Finer Than the No. 200 (75-Micrometer) Sieve
ASTM D1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(1991) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft (2,700 kN-m/m))
ASTM D1586	(1984; R 1992) Penetration Test and Split-Barrel Sampling of Soils
ASTM D1883	(1994) CBR (California Bearing Ratio) of Laboratory-Compacted Soils

ASTM D2434	(1968; R 1994) Permeability of Granular Soils (Constant Head)
ASTM D2487	(1993) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2855	(1996) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D2922	(1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D3017	(1996) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D3212	(1996; Rev. A) Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Seals
ASTM D3786	(1987) Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method
ASTM D4253	(1993) Maximum Index Density of Soils Using a Vibratory Table
ASTM D4254	(1991) Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(1995; Rev. A) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4355	(1992) Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
ASTM D4491	(1996) Water Permeability of Geotextiles by Permittivity
ASTM D4533	(1991; R 1996) Trapezoid Tearing Strength of Geotextiles
ASTM D4632	(1991; R 1996) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(1995) Determining Apparent Opening Size of a Geotextile
ASTM D4759	(1988; R 1996) Determining the Specification Conformance of Geosynthetics
ASTM D4833	(1988; R 1996) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM F402	(1993) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

ASTM F758	(1995) Smooth-Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE EM-385-1-1	(1992) Safety and Health Requirements Manual

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR	(April 1984) Soil Survey Investigation Report No. 1, Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Conservation Service

STATE OF NORTH CAROLINA, DEPARTMENT OF TRANSPORTATION

1.2 DEFINITIONS

1.2.1 Backfill

A specified material used in refilling a cut, trench, or other excavation, placed at a specified degree of compaction.

1.2.2 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.3 Cohesive Materials

Cohesive materials include materials classified by ASTM D2487 as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines have a plasticity index greater than zero.

1.2.4 Cohesionless Materials

Cohesionless materials include materials classified by ASTM D2487as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines have a plasticity index of zero.

1.2.5 Compaction

The process of mechanically stabilizing a material by increasing its density at a controlled moisture condition. "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure described in or ASTM D1557 for general soil types abbreviated in this specification as "X percent ASTM D 1557 maximum density."

1.2.6 Controlled Backfill

A specified soil mix or gradation of materials constructed to attain maximum bearing strength and minimize consolidation or differential settlement under a load. Controlled fill is sometimes called "structural fill."

1.2.7 Embankment

A "fill" having a top that is higher than adjoining ground.

1.2.8 Excavation

The removal of soil, rock, or hard material to obtain a specified depth or elevation.

1.2.9 Fill

Specified material placed at a specified degree of compaction to obtain an indicated grade or elevation.

1.2.10 Hard Material

Weathered rock, dense consolidated deposits or conglomerate materials, (excluding manmade materials such as concrete) which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment with ripper teeth or the use of jack hammers for removal. Material indicated in the soil boring logs as having a standard penetration resistance as determined by ASTM D1586 between 60 and 600 blows per foot is arbitrarily defined herein as "Hard Material."

1.2.11 In Situ Soil

Existing in place soil.

1.2.12 Lift

A layer (or course) of soil placed on top of a previously prepared or placed soil.

1.2.13 Soil

The surface material of the earth's crust resulting from the chemical and mechanical weathering of rock and organic material.

1.2.14 Subgrade

The material in excavation (cuts) and fills (embankments) immediately below any subbase, base, pavement, or other improvement. Also, as a secondary definition, the level below which work above is referenced.

1.2.15 Topsoil

In natural or undisturbed soil formations, the fine-grained, weathered material on the surface or directly below any loose or partially decomposed organic matter. Topsoil may be a dark-colored, fine, silty, or sandy material with a high content of well decomposed organic matter, often containing traces of the parent rock material. Gradation and material requirements specified herein apply to all topsoil references in this contract. The material shall be representative of productive soils in the vicinity.

1.2.16 Unsatisfactory Material

Existing, in situ soil or other material which can be identified as having insufficient strength characteristics or stability to carry intended loads in fill or embankment without excessive consolidation or loss of stability. Materials classified as PT, OH, or OL by ASTM D2487 are unsatisfactory. Unsatisfactory materials also include man-made fills, refuse, frozen material, uncompacted backfills from previous construction, unsound rock or soil lenses, or other deleterious or objectionable material.

1.2.17 Working Platform

A layer of compacted crushed rock or natural stone that replaces the in situ soil to provide a stable, uniform bearing foundation for construction equipment to facilitate further site construction.

1.3 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

Test Reports

Topsoil tests

Fill tests

Backfill tests

Granular fill tests

1.4 REGULATORY REQUIREMENTS

Materials and workmanship specified herein with reference to DOT State Standard shall be in accordance with the referenced articles, sections and paragraphs of the standard except that contractual and payment provisions do not apply.

1.5 DELIVERY AND STORAGE

Deliver and store materials in a manner to prevent contamination or segregation. Store synthetic fiber filter cloth to prevent exposure to direct sunlight in accordance with the manufacturer's recommendations.

1.6 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations as indicated.

b. No pipes or other man-made obstructions, except those indicated, will be encountered.

c. The character of the material to be excavated or used for subgrade is as indicated.

d. Ground water elevations indicated are those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

e. Suitable backfill and fill material in the quantities required is available at the project site

1.7 SITE CONDITIONS

1.7.1 Dewatering Plan

Base on site surface and subsurface conditions and available soils and hydrological data.

1.7.2 Utilities

Contact the Engineer 72 hours prior to construction for the location of all existing underground utilities. Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Contact the utility companies for location(s) of their utilities. Perform work adjacent to privately owned utilities in accordance with procedures outlined by the utility company. Excavation made with power-driven equipment is not permitted within two feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work as affected by the contract excavation until approval for backfill is granted by the Engineer. Report damage to utility lines or subsurface construction immediately to the Engineer.

1.8 QUALITY ASSURANCE

1.8.1 Shoring and Sheeting Plan

Describe materials or shoring system to be used. Indicate whether or not any components will remain after filling or backfilling. Provide plans, sketches, or details along with calculations by a registered professional engineer. Indicate sequence and method for installation and removal.

1.8.2 Dewatering System

Describe methods to be employed in removing water from exposed surfaces and diverting surface water from other areas or structures.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Granular Fill

2.1.1.1 Capillary Water Barrier

Provide a capillary water barrier under concrete floor slabs consisting of clean crushed granite stone, crushed gravel, or uncrushed gravel conforming to ASTM C33 coarse aggregate grading size 57, 67, or 7. Underlay the capillary water barrier by a synthetic fiber filter fabric conforming to the requirements specified herein.

2.1.1.2 Fill for Subsurface Drains

Provide clean sand, stone, or gravel fill meeting the following requirements:

a. Any type pipe used with filter fabric: Provide clean gravel or crushed stone or gravel conforming to ASTM C33 coarse aggregate grading size 57, 67, or 7

2.1.2 Soil Materials

Provide materials free from debris, roots, wood, scrap materials, vegetable matter, refuse or frozen material. Maximum particle size permitted is 3 inches. Use excavated material from the site for the work indicated when material falls within the requirements specified herein.

2.1.2.1 Controlled Backfill

Backfill and fill material should be a sand-clay (SC) soil as classified by ASTM D2487. In addition, this material should meet the following criteria; the liquid limit shall not exceed 35 percent when tested in accordance with ASTM D4318, the plasticity index shall not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight shall be finer than No. 200 sieve when tested in accordance with ASTM D1140. It should be placed in thin successive layers 8" to 10" loose measurement and each layer should be compacted to at least 95% of its maximum laboratory dry density, within +/- 2% of its optimum moisture content, in accordance with ASTM D1557 (modified proctor). In place field density tests should be performed in accordance with ASTM D2922 Nuclear Density or ASTM D1556 Sand Cone Density, as this material is being placed and compacted in order to ensure that required density is being achieved.

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

2.1.2.2 General Backfill Beside Structures

Soft, spongy, highly plastic, or otherwise unstable material is prohibited. Material shall be classified as SC. If more material is required than is available from on-site excavation, then provide that material from approved sources.

2.1.2.3 General Site Fill, Backfill and Embankment Material

Materials shall be classified as SC.

2.1.2.4 Working Platform

Material and thicknesses of working platform for support of construction equipment shall be at the discretion of the construction contractor. The gradation and placement of such material shall not create large void spaces upon which overlying work is indicated to be placed.

2.1.2.5 Topsoil

Provide salvaged topsoil from stockpile. Prior to spreading, test the topsoil, and add the necessary soil modifiers to bring the material within the ranges specified in Table II. Provide additional topsoil from approved sources off the site meeting the requirement described in Table II if stockpiled material is not sufficient to complete all indicated work.

Provide material free of subsoil, stumps, rocks larger than 3/4 inch diameter (with maximum 3 percent retained on 1/4 inch screen), brush, weeds, toxic substances, and other material or substance detrimental to plant growth. Topsoil shall be a natural, friable soil representative of productive soils in the vicinity. Modify topsoil provided if necessary conform with the requirements specified in Table II.

TABLE II

DOA SSIR Laboratory Test for:	Acceptable Limits
Sand Content	20 - 45 percent by weight
Silt Content	25 - 50 percent by weight
Clay Content	10 - 30 percent by weight
Organic Material (Walkley-Block)	5 percent minimum
pH	5.0 to 7.6
Soluble Salts	600 ppm maximum
Absorption Rate	0.5 inch per hour minimum

2.2 FILTER FABRIC

Provide a pervious sheet of polyester, nylon, glass or polypropylene, ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a nonraveling fabric with uniform thickness and strength. The fabric shall have the following manufacturer certified minimum average roll properties as determined by ASTM D4759:

	Class A	Class B
Grab tensile strength (ASTM D4632) machine and transversed direction	min. 180	80 lbf
Grab elongation (ASTM D4632) machine and transverse direction	min. 15	15 percent
Puncture resistance (ASTM D4833)	min. 80	25 lbf
Mullen burst strength (ASTM D3786)	min. 290	130 psi
Trapezoidal tear strength (ASTM D4533)	min. 50	25 lbf
Apparent opening size	See Criteria Below	

(ASTM D4751)	
Soil with 50 percent or less particles by weight passing US No. 200 Sieve, AOS less than 0.6mm (greater than No. 30 US Std. Sieve)	
Soil with more than 50 percent particles by weight passing US No. 200 Sieve, AOS less that 0.297 mm (greater than No. 50 US Std. Sieve)	
Permeability (ASTM D4491)	k fabric greater than k soil
Ultraviolet Degradation (ASTM D4355)	70 Percent Strength Retained at 150 hours

2.3 SUBSURFACE DRAIN PIPE

Type and size indicated conforming to the requirements specified below:

2.3.1 Plastic Pipe

2.3.1.1 Polyvinyl Chloride (PVC) Solid Wall Pipe and Fittings

ASTM F758, type PS 46, with solvent cement joints made in accordance with ASTM D2855. ASTM F402 for safe handling of solvent cement.

2.3.1.2 Polyvinyl Chloride (PVC) Perforated Pipe and Fittings

ASTM F758 type PS 28 with 3/8 inch maximum diameter holes, 3 1/4 inches on center. Diameter of pipe shall be as shown on the drawings. Make solvent cement joints in accordance with ASTM D2855. ASTM F402 for safe handling of solvent cement.

2.4 MATERIAL FOR RIP-RAP

Filter fabric and rock conforming to these requirements for construction indicated.

2.4.1 Rock

Rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Rock fragments shall be free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. The size of the fragments shall be such that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Specific gravity of the rock shall be a minimum of 2.50. The inclusion of more than trace one percent quantities of dirt, sand, clay, and rock fines will not be permitted.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Shoring and Sheeting

Provide shoring bracing cribbing underpinning and sheeting where required. In addition to Section 25 A and B of COE EM-385-1-1, and other requirements of this contract meet the following:

a. Prevent undermining of pavements, foundations and slabs.

b. Slope banks where space permits.

c. Where shoring and sheeting materials remain in place in completed work to prevent settlements or damage to adjacent structures or as directed, backfill the excavation to 3 feet below the finished grade and remove the remaining exposed portion of the shoring before completing the backfill.

3.1.2 Drainage and Dewatering

Plan for and provide the structures, equipment, and construction for the collection and disposal of surface and subsurface water encountered in the course of construction.

3.1.2.1 Drainage

Dispose of surface water which may accumulate in open excavations, unfinished fills, or other low areas. Remove water by trenching where approved, pumping, or other methods to prevent softening of exposed surfaces. Surface dewatering plan shall include rerouting of any storm water runoff or natural drainage if necessary.

3.1.2.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing or excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 3 feet below the working level.

Operate the dewatering system until construction work below existing water levels is complete. Measure and record the performance of the dewatering system at the same time each day by use of observation wells and piezometers installed in conjunction with the dewatering system.

3.1.3 Protection and Restoration of Surfaces

Protect newly graded areas from traffic, erosion, and settlements. Repair and reestablish damaged or eroded slopes, elevations or grades and restore surface construction prior to acceptance. Protect existing streams, ditches and storm drain inlets from water-borne soil by means of filter fabric dams as indicated.

3.1.3.1 Disposal of Excavated Material

Dispose of excavated material in such a manner that it will not obstruct the flow of runoff, streams, endanger a partly finished structure, impair the efficiency or appearance of facilities, or be detrimental to the completed work.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Perform as specified in Section 02231N, "Clearing and Grubbing."

3.2.2 Stockpiling Topsoil

Strip approved topsoil where excavation or grading is indicated and stockpile separately from other excavated material. Locate topsoil so that the material can be used readily for the finished grading. Protect and store in segregated piles until needed.

3.2.3 Unsatisfactory Material

Remove organic matter, sod, muck, rubbish, and unsuitable soils under embankments which are less than 3 feet in thickness and under pavements or slabs on grade. Typical depth of removal of such unsuitable material shall be 12 inches.

3.2.3.1 Subgrade Proof Rolling

After removal of topsoil or other overburden, proof roll the existing subgrade with six passes of a minimum 15 ton pneumatic-tired roller. Operate the roller in a systematic manner to assure the number of passes over all areas, and at speeds between 2.5 and 3.5 miles per hour. When proof rolling under structures, one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Proof rolling shall be done in the presence of the Engineer. Rutting or pumping shall indicate unsatisfactory material and that material shall be undercut as directed by the Engineer, to a depth of 12 inches, and replaced with the appropriate fill material. Perform proof rolling only when weather conditions permit. Do not proof roll wet or saturated subgrades. Materials degraded by proof rolling a wet or saturated subgrade shall be replaced by the Contractor as directed by the Engineer at no cost to the Owner. Notify the Engineer 3 days prior to proof rolling.

3.3 EXCAVATION

Excavate to contours and dimensions indicated. Keep excavations free from water while construction is in progress. Notify the Engineer immediately in writing in the event that it becomes necessary to remove rock, hard material, or other material defined as unsatisfactory to a depth greater than indicated and an adjustment in contract price will be considered in accordance with the Contract clause entitled "Differing Site Conditions." Refill excavations cut below the depths indicated with controlled fill and compact as specified herein. Excavate soil disturbed or weakened by construction operations or soils soften from exposure to weather. Refill with controlled fill and compact as specified herein.

3.3.1 Excavations for Structures and Spread Footings

Excavate to depth indicated. If excavation is deeper than indicated, then fill with concrete when the foundations or footings are placed

3.3.2 Subsurface Drain Trenches

Excavate in accordance with lines, grades, and sections indicated.

3.3.3 Shoring and Sheeting

Shore and sheet excavations as described in the submitted plan, with various members sized and arranged to prevent injury to persons and damage to structures. Also arrange shoring and sheeting to preclude injurious caving during removal.

3.4 FILLING AND BACKFILLING

3.4.1 Subgrade Preparation

Scarify the underlying subgrade surface to a depth of 6 inches before the fill is started. Step, bench, or break up sloped surfaces steeper than one vertical to 4 horizontal so that the fill material will bond with or be securely keyed to the existing material. Scarify existing surface to a minimum depth of 6 inches if subgrade density is less than the degree of compaction specified and recompact. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and recompact as specified for the adjacent or overlying fill. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.4.2 Fill and Backfill Beside Structures

Place required backfill material adjacent to structures and compact in a manner that prevents wedging action or eccentric loading upon or against the structures. Step or serrate slopes bounding or within areas to be backfilled to prevent sliding of the fill. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Do not place material on surfaces that are muddy, frozen, or contain frost. Do not use equipment for backfilling operations or for the formation of embankments against structures that will overload the structure. Backfilling against concrete will be done only after the concrete has attained 75% of its 28-day compressive strength.

3.4.3 Controlled Backfill

Place controlled backfill in loose lifts of 8 inches. Do not place material on surfaces that are muddy, frozen, or contain frost. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Compact each lift as specified herein before placing the overlaying lift. Compaction shall be accomplished continuously over the entire area. Sufficient passes shall be made to ensure that specified density is obtained.

3.4.4 General Fill, and General Backfill

Construct fill, backfill and embankment at the locations and to lines and grades indicated. Use only approved materials in constructing fill on the prepared subgrade. Place satisfactory material in horizontal lifts not exceeding 8 inches in loose depth. Do not place material on surfaces that are muddy, frozen, or contain frost. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Compact each lift as specified before placing the overlaying lift.

3.4.5 Final Backfill for Utilities

Construct backfill (final backfill) for storm drains, manholes, utility lines, and other utility appurtenances using the material and compaction requirements specified herein for the adjacent or overlying work. Bedding and initial backfill requirements are specified in Section 02316, "Excavation, Trenching, and Backfilling for Utilities Systems." Backfilling against concrete will be done only after the concrete has attained 75% of its 28-day compressive strength.

3.4.6 Fill for Capillary Water Barrier

Place granular fill on synthetic fiber filter fabric over compacted subgrade. Compact granular fill in lifts of 4 inches with a minimum of two passes of a hand-operated plate type vibratory compactor per lift.

3.4.7 Fill for Subsurface Drains

Install drain and construct filter of granular fill as indicated and as described below using materials specified herein. Place granular fill in 6 inch lifts and tamp or vibrate firmly. Place final backfill in trench in 6 inch lifts and compact as specified herein for adjacent or overlying work.

a. Subsurface Drain Fill Using Filter Fabric: Provide a layer of filter fabric around the perimeter of the drainage trench allowing sufficient fabric on top to provide an overlap of at least three pipe diameters. All fabric joints placed on the side of the drainage trench shall have the inside layer of filter fabric facing down. Wrap the perforated pipe with one layer of filter fabric overlapping 6 inches at the longitudinal fabric joint. Place filter fabric around the pipe so that at the overlap the outer layer of fabric is facing down and in direct contact with the inner layer of fabric and the pipe. Obtain approval of filter fabric installation before placing fill. Place fill in a manner to prevent fabric damage or displacement.

3.4.8 Weather Limitations

Fill and backfill shall not be constructed when weather conditions detrimentally affect the quality of the finished course. Place fill and backfill only if the atmospheric temperature is above freezing in the shade and is rising. Do not construct fill and backfill in the rain or on saturated subgrades. If weather conditions are windy, hot or arid, with high rate of evaporation, schedule the placement in cooler portions of the day and furnish equipment to add moisture to the fill or backfill during and after placement.

3.5 INSTALLATION OF PIPE FOR SUBSURFACE DRAINS

3.5.1 Pipelaying

Do not lay damaged or defective pipe. Laying of pipe shall proceed upgrade beginning at lower end of the pipeline. Pipe shall not be laid in water or when the trench conditions or weather is unsuitable for such work. Remove water from trenches by sump pumping or other approved methods. Lay pipe to the grades and alignment as indicated. Bed pipe to the established gradeline. Orient perforations on the bottom half of the pipe. Lay bell-and spigot or tongue-and-groove type pipe with the bell or groove end upstream. Obtain approval for pipe in place before backfilling.

3.5.2 Jointing

3.5.2.1 Poly(Vinyl Chloride) (PVC) Pipe

Joints shall be in accordance with the requirements of ASTM D3212.

3.6 SUBGRADE FILTER FABRIC

Place synthetic fiber filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inches diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.7 COMPACTION

Compact each layer or lift of material specified so that the in-place density tested is not less than the percentage of maximum density specified in Table III.

TABLE III

Percent ASTM D1557
Maximum Density

	Cohesive Material	Cohesionless Material
Fill, Embankment and Backfill		
General Backfill under steps and parking lots	95	98
General Backfill under sidewalks and grassed areas	85	90
General Backfill beside structures	90	95
Controlled backfill under footings, pavements and structures	95	100
Under Roadways, top 12 inches	98	98
Subgrade (Top of fill, backfill or cut)		
Under building slabs, steps and parking lots, top 12 inches	95	98

Under footings, top 12 inches	95	100
Under sidewalks, and grass areas, top 6 inches	85	90

3.8 FINISH OPERATIONS

3.8.1 Site Grading

Grade to finished grades indicated within 0.10 foot. Grade areas to drain water away from structures and to provide suitable surfaces for mowing machines. Existing grades which are to remain but are disturbed by the Contractor's operations shall be restored.

3.8.2 Finishing Subgrades Under Structures and Pavements

Finish surface of top lift of fill or top of subgrade to the elevation and cross section indicated. Finished surface shall be smooth and of uniform texture. Lightly scarify or blade the finished surface to bring the finished surface to within 0.05 foot of the indicated grade and to eliminate imprints made by compaction and shaping equipment. Surface shall show no deviations in excess of 3/8 inch when tested with a 10 foot straightedge.

3.8.3 Spreading Topsoil

Clear areas indicated or specified to receive topsoil of materials interfering with planting and maintenance operations. Do not place topsoil when subgrade is frozen, extremely wet or dry, or in other conditions detrimental to seeding, planting, or grading. Spread topsoil to a uniform depth of 4 inches over the disturbed areas.

3.8.4 Disposition of Surplus Material

Surplus or other soil material not required or suitable for filling, backfilling, or embankment shall be wasted by disposition in the area indicated. Spread and level wasted material and grade to the elevations indicated.

3.8.5 Protection of Surfaces

Protect newly graded areas from traffic, erosion, and settlements that may occur as specified in the paragraph entitled "Protection and Restoration of Surfaces." Repair or reestablish damaged grades, elevations, or slopes prior to acceptance of work.

3.9 FIELD QUALITY CONTROL

3.9.1 Sampling

Furnish one 50 pound composite sample for each 500 cubic yards of subgrade being compacted and fill material being placed. Submit samples, in the number directed, whenever the source or character of the fill, backfill, or embankment material changes. Contain each sample in a clean container and fasten to prevent loss of material. Tag each sample for identification. Tag shall contain the following information:

Contract No. ____________________

Sample No. ______________________
Date of Sample _________________
Sampler ________________________
Source _________________________
Intended Use ___________________

3.9.2 Tests

Test backfill using ASTM C136for conformance to ASTM C33, and ASTM D2487 gradation limits. Test backfill for liquid limit and plasticity index using ASTM D4318. Test backfill and subgrade in cut materials for moisture density relations using ASTM D1557. Test backfill for permeability in accordance with ASTM D2434. Perform density tests in randomly selected locations using ASTM 1556 as follows: one test per 18,000square feet in each layer of lift 500 cubic yards placed, 1,000 square yards subgrade in cut. Determine moisture content of soil material in place at every location where in-place density is tested.

-- End of Section --

SECTION 31 23 33

EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))
ASTM D 2487	(1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)

1.2 DEGREE OF COMPACTION

Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557.

1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Test Reports

Field Density Tests;
Testing of Backfill Materials;

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Satisfactory Materials

Satisfactory materials shall comprise any materials classified by ASTM D 2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material, and stones larger than 2 inches. The Engineer shall be notified of any contaminated materials.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials shall include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials shall include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM shall be identified as cohesionless only when the fines are nonplastic.

2.1.4 Unyielding Material

Unyielding material shall consist of rock and gravelly soils with stones greater than 6 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller.

2.1.5 Unstable Material

Unstable material shall consist of materials too wet to properly support the utility pipe, conduit, or appurtenant structure.

2.1.6 Select Granular Material

Select granular material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall contain not more than 10 percent by weight of material passing a No. 200 mesh sieve and no less than 95 percent by weight passing the l inch sieve. The maximum allowable aggregate size shall be 1 inch, or the maximum size recommended by the pipe manufacturer, whichever is smaller.

2.1.7 Initial Backfill Material

Initial backfill shall consist of select granular material or satisfactory materials free from rocks 1-1/2 inch or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, the initial backfill material shall be free of stones larger than 1 inch in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

2.2 PLASTIC MARKING TAPE

Plastic marking tape shall be acid and alkali-resistant polyethylene film, 6 inches wide with minimum thickness of 0.004 inch. Tape shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise. The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The tape shall be of a type specifically manufactured for marking and locating underground utilities. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion. Tape color shall be as specified in TABLE 1 and shall bear a continuous printed inscription describing the specific utility.

TABLE 1. Tape Color

Red:	Electric

Yellow:	Gas, Oil, Dangerous Materials
Orange:	Telephone, Telegraph, Television, Police, and Fire Communications
Blue:	Water Systems
Green:	Sewer Systems

2.3 DETECTION WIRE FOR NON-METALIC PIPING

Detection wire shall be insulated single strand, solid copper with a minimum diameter of 12 AWG.

PART 3 EXECUTION

3.1 EXCAVATION

Excavation shall be performed to the lines and grades indicated. Earth excavation shall include removal and disposal of material. During excavation, material satisfactory for backfilling shall be stockpiled in an orderly manner at a distance from the banks of the trench equal to 1/2 the depth of the excavation, but in no instance closer than 2 feet. Excavated material not required or not satisfactory for backfill shall be stockpiled on site. Grading shall be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating shall be removed to maintain the stability of the bottom and sides of the excavation. Unauthorized over excavation shall be backfilled in accordance with paragraph BACKFILLING AND COMPACTION at no additional cost to the Owner.

3.1.1 Trench Excavation Requirements

The trench shall be excavated as recommended by the manufacturer of the pipe to be installed. Trench walls below the top of the pipe shall be sloped, or made vertical, and of such width as recommended in the manufacturer's installation manual. Where no manufacturer's installation manual is available, trench walls shall be made vertical. Trench walls more than 4 feet high shall be shored, cut back to a stable slope, or provided with equivalent means of protection for employees who may be exposed to moving ground or cave in. Vertical trench walls more than 6 feet high shall be shored. Trench walls, which are cut back, shall be excavated to at least the angle of repose of the soil. Special attention shall be given to slopes which may be adversely affected by weather or moisture content. The trench width below the top of pipe shall not exceed 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter and shall not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, redesign, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of redesign, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the Owner.

3.1.1.1 Bottom Preparation

The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes shall be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 1-1/2 inches or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.

3.1.1.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, such material shall be removed 3 inches below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.1.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Owner.

3.1.1.4 Excavation for Appurtenances

Excavation for manholes, catch-basins, inlets, or similar structures shall be sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members. All such structures shall be placed on a prepared foundation of 12 inches of No. 57 stone, which will extend 12 inches beyond the outside dimension of the structure, on all sides. Removal of unstable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

3.1.1.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, excavation shall be by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Engineer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.1.2 Stockpiles

Stockpiles of satisfactory and unsatisfactory and wasted materials shall be placed and graded as specified. Stockpiles shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed by rubber-tired equipment. Excavated satisfactory and unsatisfactory materials shall be separately stockpiled. Stockpiles of satisfactory materials shall be protected from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, such material shall be removed and replaced with satisfactory material from approved sources at no additional cost to the Owner.

3.2 BACKFILLING AND COMPACTION

Backfill material shall consist of satisfactory material, select granular material, or initial backfill material as required. Backfill shall be placed in layers not exceeding 6 inches loose thickness for compaction by hand operated machine compactors, and 8 inches loose thickness for other than hand operated machines, unless otherwise specified. Each layer shall be compacted to at least 95 percent maximum density for cohesionless soils and 90 percent maximum density for cohesive soils, unless otherwise specified.

3.2.1 Trench Backfill

Trenches shall be backfilled to the grade shown. The trench shall be backfilled to a minimum of 2 feet above the top of pipe prior to performing the required pressure tests.

3.2.1.1 Replacement of Unyielding Material

Unyielding material removed from the bottom of the trench shall be replaced with select granular material or initial backfill material.

3.2.1.2 Replacement of Unstable Material

Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 6 inches loose thickness. Payment for select backfill shall be included in the linear foot price of pipe.

3.2.1.3 Bedding and Initial Backfill

Bedding shall be of the type and thickness shown on drawings. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.

3.2.1.4 Final Backfill

The remainder of the trench, except for special materials for roadways, shall be filled with satisfactory material. Backfill material shall be placed and compacted as follows:

a. Roadways: Backfill shall be placed up to the elevation at which the requirements in Section 02301 EARTHWORK control. Water flooding or jetting methods of compaction will not be permitted.

b. Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Backfill shall be deposited in layers of a maximum of 12 inch loose thickness, and compacted to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Compaction by water flooding or jetting will not be permitted. This requirement shall also apply to all other areas not specifically designated above.

3.2.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.3 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.3.1 Water Lines

Trenches shall be of a depth to provide a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.3.2 Electrical Distribution System

Direct burial cable and conduit or duct line shall have a minimum cover of 24 inches from the finished grade, unless otherwise indicated. Special trenching requirements for direct-burial electrical cables and conduits (if necessary) shall be as specified in Division 16 - Electrical.

3.3.3 Plastic Marking Tape and Detection Wire

Warning tapes and detection wire shall be installed directly above the pipe, at a depth of 18 inches below finished grade unless otherwise shown.

3.4 TESTING

Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Owner.

3.4.1 Testing Facilities

Tests shall be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved by the Engineer.

3.4.2 Testing of Backfill Materials

Classification of backfill materials shall be determined in accordance with ASTM D 2487 and the moisture-density relations of soils shall be determined in accordance with ASTM D 1557. A minimum of one soil classification and one moisture-density relation test shall be performed on each different type of material used for bedding and backfill.

3.4.3 Field Density Tests

Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained. Frequency of field density tests shall conform to NCDOT standards. Field in-place density shall be determined in accordance with ASTM D 1556. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the Owner.

3.4.4 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to the finished grade surface, the pipe shall be inspected to determine whether significant displacement has occurred. This inspection shall be conducted in the presence of the Engineer. Pipe sizes larger than 36 inches shall be entered and examined, while smaller diameter pipe shall be inspected by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Engineer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, the defects shall be remedied as directed at no additional cost to the Owner.

-- End of Section --

SECTION 31 31 16

TERMITE CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Chemical soil treatment for termite control.

B. Related Requirements:
   1. Section 03 30 00 - Cast-In-Place Concrete: Slabs on grade placed over treated soil.

1.2 REFERENCES

A. U.S. Environmental Protection Agency (EPA):
   1. EPA Title 7, United States Code, 136 through 136y - Federal Insecticide, Fungicide and Rodenticide Act (FIFRA); 2006.

1.3 SEQUENCING

A. Section 01 30 00 - Administrative Requirements and Section 00 10 00 - Summary: Scheduling and sequencing.

B. Apply toxicant 12 hours prior to installation of vapor barrier under slabs-on-grade in accordance with product label supplemented by the NPCA’s ARP for termiticiding or local requirements.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures.

B. Product Data:
   1. Indicate toxicants to be used, composition by percentage, dilution schedule, intended application rate. Include product label information.
   2. Submit manufacturers' data on manufactured products showing compliance with specified requirements.

C. Test Reports: Indicate regulatory agency approval reports.

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

E. Certificate of compliance from authority having jurisdiction indicating approval of toxicants.

F. Manufacturer's Instructions: Indicate caution requirement.

G. Manufacturer’s Qualifications.

H. Installer’s Qualifications.

I. Maintenance Data: Indicate re-treatment schedule.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 78 23 - Operation and Maintenance Data.

B. Project Record Documents: Record and document the following:
   1. Moisture content of soil before application.
   2. Date and rate of application.
   3. Areas of application and diary of toxicity meter readings and corresponding soil coverage.

C. Warranty: Submit warranty and ensure that forms have been completed in Owner's name.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing Products specified in this Section with minimum three years documented experience.
B. Installer Qualifications: Company specializing in performing this type of work and:
   1. Having minimum of five (5) years documented experience.
   2. Approved by manufacturer of treatment materials.
   3. Licensed in the State in which the Project is located.

1.7 WARRANTY

A. Section 01 77 00 - Closeout Procedures: Product warranties.
B. Provide five (5) year installer's warranty against damage to building caused by termites.
   1. Include coverage for repairs to building and to contents damaged due to building damage. Repair damage and re-treat areas.
   2. Include provision for installer to inspect and report annually to Owner in writing for duration of warranty period.

PART 2 PRODUCTS

2.1 CHEMICAL SOIL TREATMENT

A. Toxicant Chemical: Registered (licensed) by EPA; approved in accordance with Title 7, United States Code, 136 through 136y - FIFRA; approved by local authority having jurisdiction; synthetically color dyed to permit visual identification of treated soil.
B. Diluent: Recommended by toxicant manufacturer.
C. Manufacturers:
   1. BASF.
   2. Bayer Environmental Science Corporation.
   3. Corteva Agriscience.
   4. FMC Specialty Solutions.
   5. Syngenta Professional Products.
   6. Substitutions: Section 01 60 00 - Product Requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 73 00 - Execution: Verification of existing conditions before starting work.
B. Verify soil surfaces are unfrozen, sufficiently dry to absorb toxicant, and ready to receive treatment.
C. Verify final grading and excavations are complete.
D. Prepare field conditions and existing construction for installation of work of this Section.
E. Prepare materials to be installed and equipment used during installation.

3.2 APPLICATION - CHEMICAL SOIL TREATMENT

A. Section 01 73 00 - Execution: Related to installation of Work.
B. Comply with requirements of U.S. EPA and applicable state and local codes.
C. Comply with manufacturer's written instructions.
D. Mix toxicant in accordance with manufacturer’s instructions.
E. Record and maintain Project Record Documents indicated in CLOSEOUT SUBMITTALS article of this Section.
F. Spray apply toxicant in accordance with manufacturer's instructions.
G. Apply toxicant at following locations:

1. Under slabs-on-grade.
2. In crawl spaces.
3. At both sides of foundation surface.
4. Soil within 5 feet of building perimeter for a depth as recommended by manufacturer.
5. Other locations as indicated on Drawings.

H. Under slabs, apply toxicant immediately prior to installation of vapor barrier.

I. At foundation walls, apply toxicant immediately prior to finish grading work outside foundations.

J. Apply extra treatment to structure penetration surfaces such as pipe or ducts, and soil penetrations such as grounding rods or posts.

K. Re-treat disturbed treated soil with same toxicant as original treatment.

L. If inspection or testing identifies the presence of termites, re-treat soil and re-test.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01 73 00 - Execution: Protecting installed construction.

B. Do not permit soil grading over treated work.

END OF SECTION

SECTION 32 11 23

GRADED CRUSHED AGGREGATE BASE COURSE FOR FLEXIBLE PAVEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	(1991; Rev. A) Unit Weight and Voids in Aggregate
ASTM C 117	(1995) Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996; Rev. A) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 75	(1987; R 1992) Sampling Aggregates
ASTM D 1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft (2,700 kN-m/m))
ASTM D 1883	(1994) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D 2217	(1985; R 1993) Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
ASTM D 2922	(1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1996) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4318	(1995; Rev. A) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

Test Reports

Gradation

Bearing ratio

Liquid limit

Plasticity index

Percentage of wear

Density

Gradation

Smoothness

Density

Thickness

1.3 DELIVERY AND STORAGE

Inspect materials delivered to site for damage and store as to prevent segregation and contamination.

1.4 WEATHER LIMITATIONS

Do not construct base course when atmospheric temperature is below 35 degrees F or when rainfall or other weather conditions detrimentally affect the quality of the finished course.

1.5 CONSTRUCTION EQUIPMENT

Equipment shall be dependable and adequate for the purpose intended. Maintain equipment in satisfactory and safe operating condition. Subject to approval, special equipment dictated by local conditions may be used. Calibrated equipment, such as scales, batching equipment, spreaders, and similar items, shall have been recalibrated by an approved calibration laboratory within 12 months of commencing work.

PART 2 PRODUCTS

2.1 MATERIALS

Materials shall conform to North Carolina DOT Standard Specifications for Highway Construction.

PART 3 EXECUTION

3.1 CONSTRUCTION AND TESTING REQUIREMENTS

The base shall be constructed and tested in accordance with the North Carolina DOT Standard Specifications for Highway Construction. Construct the graded aggregate base course on a prepared subgrade as indicated. Provide line and grade stakes for control. Place grade stakes in lanes parallel to the centerline of areas to be paved and space for string lining or other control methods. The base course shall consist of aggregate processed, deposited, spread, and compacted on a prepared surface. The Contractor shall be responsible for protection of completed areas against detrimental effects. Recondition, reshape, and recompact areas damaged by freezing, rainfall, or other weather conditions.

-- End of Section --

SECTION 32 12 16

HOT MIX BITUMINOUS PAVEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASPHALT INSTITUTE (AI)

AI MS-2	(1994) Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	(1991; Rev. A) Unit Weight and Voids in Aggregate
ASTM C 88	(1990) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	(1995) Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(1988; R 1993) Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	(1993) Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996; Rev. A) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 188	(1995) Density of Hydraulic Cement
ASTM D 70	(1982; R 1990) Specific Gravity of Semi-Solid Bituminous Materials
ASTM D 75	(1987; R 1992) Sampling Aggregates
ASTM D 242	(1995) Mineral Filler for Bituminous Paving Mixtures
ASTM D 546	(1994) Sieve Analysis of Mineral Filler for Road and Paving Materials

ASTM D 692	(1994; Rev. A) Coarse Aggregate for Bituminous Paving Mixtures
ASTM D 854	(1992) Specific Gravity of Soils
ASTM D 946	(1982; R 1993) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 979	(1996) Sampling Bituminous Paving Mixtures
ASTM D 995	(1995; Rev. B) Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	(1994) Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1075	(1996) Effect of Water on Cohesion of Compacted Bituminous Mixtures
ASTM D 1188	(1996) Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1559	(1989) Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 2041	(1995) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	(1995) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2726	(1996; Rev. A) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 3381	(1992) Viscosity-Graded Asphalt Cement for Use in Pavement Construction

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

Design Data

Test Reports

Specific gravity test of asphalt

Coarse aggregate tests

Weight of slag test

Percent of crushed pieces in gravel

Fine aggregate tests

Specific gravity of mineral filler

Bituminous mixture tests

Aggregates tests

Bituminous mix tests

Pavement courses

1.3 QUALITY ASSURANCE

1.3.1 Safety Requirements

Provide adequate and safe stairways with handrails to the mixer platform, and safe and protected ladders or other means for accessibility to plant operations. Guard equipment and exposed steam or other high temperature lines or cover with a suitable type of insulation.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage and store with a minimum of handling. Store aggregates in such a manner as to prevent segregation, contamination, or intermixing of the different aggregate sizes.

1.5 ENVIRONMENTAL CONDITIONS

Place bituminous mixture only during dry weather and on dry surfaces. Place courses only when the surface temperature of the underlying course is greater than 45 degrees F for course thicknesses greater than one inch and 55 degrees F for course thicknesses one inch or less.

1.6 CONSTRUCTION EQUIPMENT

Calibrated equipment, such as scales, batching equipment, spreaders and similar equipment, shall have been recalibrated by a calibration laboratory approved by the Engineer within 12 months of commencing work.

PART 2 PRODUCTS

2.1 GENERAL

The hot mixed bituminous pavement shall comply with the North Carolina DOT Standard Specifications for Highway Construction.

PART 3 EXECUTION

3.1 CONSTRUCTION

The hot mix bituminous pavement shall be constructed in compliance with the North Carolina DOT Standard Specifications for Highway Construction.

-- End of Section --

SECTION 32 13 13

CONCRETE DRIVEWAYS, SIDEWALKS, AND CURBS AND GUTTERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 185	(1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 615/A 615M	(1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616/A 616M	(1996a) Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617/A 617M	(1996a) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM C 31/C 31M	(1996) Making and Curing Concrete Test Specimens in the Field
ASTM C 143	(1990a) Slump of Hydraulic Cement Concrete
ASTM C 171	(1997) Sheet Materials for Curing Concrete
ASTM C 172	(1997) Sampling Freshly Mixed Concrete
ASTM C 173	(1996) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 231	(1997) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 309	(1997) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 920	(1995) Elastomeric Joint Sealants
ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

ASTM D 1752	(1984; R 1996) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 3405	(1996) Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements

1.2 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Product Data

Concrete;

Copies of certified delivery tickets for all concrete used in the construction.

Test Reports

Field Quality Control;

Copies of all test reports within 24 hours of completion of the test.

1.3 WEATHER LIMITATIONS

1.3.1 Placing During Cold Weather

Concrete placement shall not take place when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Provisions shall be made to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection shall be approved in writing. Approval will be contingent upon full conformance with the following provisions. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited. Mixing water and aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating shall be approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.3.2 Placing During Warm Weather

The temperature of the concrete as placed shall not exceed 85 degrees F except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 95 degrees F at any time.

1.4 PLANT, EQUIPMENT, MACHINES, AND TOOLS

1.4.1 General Requirements

Plant, equipment, machines, and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The Engineer shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.4.2 Slip Form Equipment

Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in 1 pass.

PART 2 PRODUCTS

2.1 CONCRETE

Concrete shall conform to the applicable requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE except as otherwise specified. Concrete shall have a minimum compressive strength of 3500 psi at 28 days. Maximum size of aggregate shall be 1-1/2 inches.

2.1.1 Air Content

Mixtures shall have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

The concrete slump shall be 4 inches plus or minus 1 inch where determined in accordance with ASTM C 143.

2.1.3 Reinforcement Steel

Reinforcement bars shall conform to ASTM A 615/A 615M, ASTM A 616/A 616M, or ASTM A 617/A 617M. Wire mesh reinforcement shall conform to ASTM A 185.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Impervious sheet materials shall conform to ASTM C 171, type optional, except that polyethylene film, if used, shall be white opaque.

2.2.2 Burlap

Burlap shall conform to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

White pigmented membrane-forming curing compound shall conform to ASTM C 309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.4.2 Expansion Joint Filler, Premolded

Expansion joint filler, premolded, shall conform to ASTM D 1751 or ASTM D 1752, 3/8 inch thick, unless otherwise indicated.

2.5 JOINT SEALANTS

2.5.1 Joint Sealant, Cold-Applied

Joint sealant, cold-applied shall conform to ASTM C 920.

2.5.2 Joint Sealant, Hot-Poured

Joint sealant, hot-poured shall conform to ASTM D 3405.

2.6 FORM WORK

Form work shall be designed and constructed to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 10 feet with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.1 Sidewalk Forms

Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

2.6.2 Curb and Gutter Forms

Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

The subgrade shall be constructed to the specified grade and cross section prior to concrete placement. Subgrade shall be placed and compacted in conformance with Section .

3.1.1 Sidewalk Subgrade

The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected to produce a subgrade free from frost when the concrete is deposited.

3.2 FORM SETTING

Forms shall be set to the indicated alignment, grade and dimensions. Forms shall be held rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Forms for sidewalks shall be set with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment shall be checked with a 10 foot straightedge. Forms shall have a transverse slope of 1/4 inch per foot] with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Concrete shall be placed in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated with an approved vibrator, and the surface shall be finished to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, the surface shall be finished with a wood float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished with an edger having a radius of 1/8 inch. Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.4 Joint Finishing

Curb edges at formed joints shall be finished as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 SIDEWALK JOINTS

Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 10 feet or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated.

3.5.1 Sidewalk Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8 inch blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Expansion joints shall be formed with 1/2 inch joint filler strips. Joint filler shall be placed with top edge 1/4 inch below the surface and shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 1/8 inch, and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be cleaned and filled with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 degrees F at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.5.3 Reinforcement Steel Placement

Reinforcement steel shall be accurately and securely fastened in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length. Contraction joints shall be constructed by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

3.6.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 1/2 inch in width shall be provided at intervals not exceeding 20 feet. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Expansion joints and the top 1 inch depth of curb and gutter contraction-joints shall be sealed with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 degrees F at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Concrete shall be protected against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Unhardened concrete shall be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

The entire exposed surface shall be covered with 2 or more layers of burlap. Mats shall overlap each other at least 6 inches. The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. The curing medium shall not be less than 18-inches wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet per gallon for the total of both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to insure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Completed concrete shall be protected from damage until accepted. The Contractor shall repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.7.4 Protective Coating

Protective coating of linseed oil mixture shall be applied to the exposed-to-view concrete surface.

3.7.4.1 Application

Curing and backfilling operation shall be completed prior to applying two coats of protective coating. Concrete shall be surface dry and clean before each application. Coverage shall be by spray application at not more than 50 square yards per gallon for first application and not more than 70 square yards per gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Material shall not be applied at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

3.8.1 General Requirements

The Contractor shall perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, the Contractor shall take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

The Contractor shall provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken not less than once a day nor less than once for every 250 cubic yards of concrete. The samples for strength tests shall be taken in accordance with ASTM C 172. Cylinders for acceptance shall be molded in conformance with ASTM C 31/C 31M by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Air content shall be determined in accordance with ASTM C 173 or ASTM C 231. ASTM C 231 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Owner inspector. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Two slump tests shall be made on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 1/4 inch. Pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Owner and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

-- End of Section --

SECTION 32 31 00

FENCES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section shall consist of furnishing and installing new fence and/or removing and salvaging existing fence and restoring the same in conformance with the lines and grades and requirements shown on the DRAWINGS. Wherever the materials to be removed are not in good condition, as judged by the ENGINEER, or wherever CONTRACTOR has damaged the materials during the process of removal, equal or better quality fencing materials than the existing shall be furnished and installed by CONTRACTOR.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):

a. M111M/M111, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

b. M133, Standard Specification for Preservatives and Pressure Treatment Processes for Timber.

c. M181, Standard Specification for Chain-Link Fence.

d. M232M/M232, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

e. M281, Standard Specification for Steel Fence Posts and Assemblies, Hot-Wrought.

2. ASTM International (ASTM):

a. A116, Standard Specification for Metallic-Coated, Steel-Woven Wire Fence Fabric.

b. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.

c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.

d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.

e. B211, Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire.

f. F537, Standard Specification for Design, Fabrication, and Installation of Fences Constructed of Wood and Related Material

3. Federal Specification (FED): FCGS-02-1, Fencing, Wire and Post, Metal (Chain-link Fence Posts, Top Rails and Braces).

PART 2 PRODUCTS

2.01 MATERIALS

A. Timber: All timber materials for new fencing shall be No. 1 grade cedar.

B. Barbed Wire: Steel barbed wire shall conform to the requirements of ASTM A121 Class I. Aluminum barbed wire shall be manufactured in accordance with ASTM B211 with alloy 5052-O for the line wire and alloy 5052-H38 for the barbs.

C. Woven Wire: Woven wire shall conform to the details and requirements shown on the DRAWINGS and to the following:

1. Zinc-coated steel woven wire shall conform to the requirements of ASTM A116, coating Class I.

2. Aluminum-coated steel woven wire shall conform to the requirements of ASTM A116, coating Class I.

3. Fittings and attachments shall be zinc coated to conform to the requirements of AASHTO M232M/M232.

D. Chain Link Fabric: Chain link fabric and required fittings and hardware shall conform to the requirements of AASHTO M181 for the kind of metal, sizes of wire and mesh specified. Zinc coating for steel fabric shall conform to ASTM A392, Class I and aluminum coating for steel fabric to ASTM A491, Class I. Fabric shall be vinyl coated in accordance with the Town of Southern Pines Requirements and shall have a color option of Black, Brown or Green.

E. Snow Fence: Wire-bound picket fence shall conform to the requirements of ASTM F537. Posts shall conform to the requirements of AASHTO M281.

F. Construction Fence: Construction fence shall be bright orange woven plastic mesh, four feet (4') minimum in height.

G. Fence Posts:

1. Wood posts shall conform to the details and dimensions indicated on the DRAWINGS. Wood posts shall be straight, sound, and seasoned with ends sawed off square or as indicated. All knots shall be trimmed flush with the surface. Wood posts shall be peeled and treated with preservative in accordance with AASHTO M133. When native cedar posts are called for on the DRAWINGS, the requirements for peeling and for treating may be omitted.

2. All dimension timber and lumber required for fences or gates shall be sound, straight, and free from knots, splits, and shakes. It shall be of the species and grades indicated on the DRAWINGS.

3. Concrete posts shall be made of concrete of the class specified, and shall contain steel reinforcement as shown on the DRAWINGS.

4. Steel posts shall be galvanized in accordance with AASHTO M111M/M111. Fittings, hardware, and other appurtenances not specifically covered by the DRAWINGS and SPECIFICATIONS shall be standard commercial grade, and in accordance with current standard practice. Pipe material for fence posts shall conform to the requirements shown on the DRAWINGS and to the requirements of Class 1 Pipe, Grade A or Grade B, of FED FCGS-02-01. Post shall be vinyl coated in accordance with the Town of Southern Pines Requirements and shall have a color option of Black, Brown or Green.

5. Construction fence posts shall be studded steel tee posts. H.Nails: All nails used for

construction shall be galvanized.

PART 3 EXECUTION

3.01 REMOVAL OF EXISTING FENCE

A. All rails, braces, posts, and the like shall be removed and disposed of or salvaged by CONTRACTOR to allow construction of the PROJECT as described on the DRAWINGS.

3.02 CONSTRUCTION OR REPLACEMENT OF FENCE

A. General:

1. CONTRACTOR shall perform such clearing and grubbing as may be necessary to construct or replace the fence to the required grade and alignment as shown on the DRAWINGS.

2. At locations where breaks in a run of fencing are required, appropriate adjustments in fence alignment and/or post spacing shall be made to satisfy requirements or conditions encountered.

B. Posts and Rails: Posts shall be securely embedded into the ground to meet the proper alignment and elevations. Posts shall be embedded in concrete as shown on the DRAWINGS. Posts and rails shall be held in proper positions by secure bracing until such time as the concrete has set sufficiently to hold the posts. Materials shall not be installed on posts, or stress placed on bracing until the concrete has set sufficiently to withstand the stress. The complete fence shall be plumb and in straight alignment as shown on the DRAWINGS or as directed by ENGINEER.

C. Construction Fence: Construction fence posts shall be installed at ten (10) feet on center and the plastic mesh shall be attached to each post at top, bottom, and center using plastic ties. A twelve and one-half (12-1/2) gage wire strand shall be installed along the top and bottom of the fence for added stability. The plastic mesh shall be attached to the top and bottom strand wires in three (3) equally spaced locations between each post using plastic ties. Construction fence shall be installed along the limits of disturbance. Construction fence shall remain in place and be repaired as necessary throughout construction.

END OF SECTION

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SECTION 32 90 00

PLANTING

PART 1 - GENERAL

1.01 References

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

B. Examine all drawings and all other sections of the Specifications for requirements therein affecting the work of this trade.

1.02 Scope: The work of this Section consists of all planting work and related items as indicated on the drawings and/or as specified herein and includes, but is not limited to, the following:

A. Loam borrow.
B. Preparation of backfill mix.
C. Planting.
D. Maintenance.
E. Guarantee.

1.03 Related Work Under Other Sections: The following items of related work are specified and included in other sections of the Specifications.

A. Site and clearing preparation.
B. Turf and Grasses.
C. Planting Irrigation.
D. Planting.

1.04 Standards and Definitions: The following standards and definitions shall apply to the work of this Section.

A. ASNS: "American Standard for Nursery Stock," ANSI 260.1, latest edition, published by the American Association of Nurserymen (AAN).

B. SPN: "Standardized Plant Names", latest edition, by the American Joint Committee on Horticultural Nomenclature.

C. AOAC: Association of Official Agricultural Chemists.

1.05 Samples and Submittals: At least seven (7) days prior to intended use, the Contractor shall provide the following samples and submittals for approval. Do not order materials until Architect's approval of samples, certifications or test results has been obtained. Delivered materials shall closely match the approved samples.

A. Loam Borrow: The Contractor shall provide a one (1) cubic foot representative sample from each proposed source for testing, analysis, and approval. Contractor shall deliver samples to testing laboratories and shall have the testing report sent directly to the Owner's representative and pay all costs. Testing reports shall include the following tests and recommendations.

1. Mechanical gradation (sieve analysis) for loam shall be performed and compared to the USDA Soil Classification System.

2. Percent of organics for loam shall be determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F., plus or minus 9 degrees.

3. Chemical analysis for loam shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Soluble Salts, and acidity (pH).

4. Tests for gradation and organics shall be performed by a private testing laboratory approved by the Owner's representative. Tests for soil chemistry and pH may be performed by a public extension service agency.

5. Soil analysis tests shall show recommendations for soil additives to correct soils deficiencies as necessary, and for fertilizing and liming applications to support successful turf growth.

6. All tests shall be performed in accordance with the current standards of the Association of Official Agricultural Chemists.

B. Fertilizer: Submit certificates of analysis and sample packet.

C. Planting mulch: Submit a two (2) cu. ft.

1.06 Examination of Conditions

A. All areas to be planted shall be inspected by the Contractor before starting work and any defects such as incorrect grading, etc., shall be reported to the Owner prior to beginning this work. The commencement of work by the Contractor shall indicate his/her acceptance of the areas to be planted, and the Contractor shall assume full responsibility for the work of this Section.

B. The Contractor shall be solely responsible for judging the full extent of work requirements involved, including but not limited to the potential need for storing and maintaining plants temporarily (heeling and watering plants in a protected area) and/or rehandling plants prior to final acceptance.

C. All plants are the full responsibility of the Landscape Contractor between the time of digging at the nursery and final installation.

PART 2 - PRODUCTS

2.01 Loam

A. Loam shall be a "fine sandy loam" or a "sandy loam" determined by mechanical analysis and based on the "USDA Classification System". It shall be of uniform composition, without admixture of subsoil. It shall be free of stones greater than two inches (2"), lumps, plants and their roots, debris and other extraneous matter as determined by the Landscape Architect. It shall not contain toxic substances harmful to plant growth. Loam shall contain not less than three percent (3%) or more than eight percent (8%) organic matter as determined by the loss on ignition of oven-dried samples.

B. If loam is available for re-use, the loam stripped and stockpiled on the site may be used provided that, after testing and addition of necessary additives, it meets the above specification. The Contractor shall provide additional loam as required to complete the required work.

C. All loam proposed for use shall be tested for prior to use, and improved as necessary to satisfy specification requirements.

D. Loam shall have an acidity range of pH 5.6 to 6.5.

2.02 Soil Additives

A. Peat, humus or other additives shall be used to counteract soil deficiencies as recommended by the soil analysis and as approved by the Landscape Architect.

B. Sulphur for adjustment of loam pH shall be commercial or flour sulphur, unadulterated, and shall be delivered in containers with the name of the manufacturer, material, analysis and net weight appearing on each container.

C. Ground limestone for adjustment of loam pH shall contain not less than eighty five percent (85%) of total carbonates and shall be ground to such fineness that forty percent (40%) will pass through 100 mesh sieve and ninety-five (95%) will pass through a 20 mesh sieve.

D. Humus shall be natural humus, reed peat or sedge peat.

E. Peat moss shall be composed of the partly decomposed stems and leaves of any of several species of sphagnum moss.

2.03 Plant Materials

A. The Contractor shall furnish all plants shown on the drawings, as specified, and in quantities listed on the Plant List. No substitutions will be permitted. All plants shall be nursery grown unless specifically authorized to be collected.

B. Plant shall be in accordance with the ASNS Standards of the American Association of Nurserymen. Botanical plant names shall be in accordance with plant designations included in Standardized Plant Names.

C. All plants shall be typical of their species or variety and shall have a normal habit of growth and be legibly tagged with the proper name. Only plant stock grown within hardiness Zones 8 through 5, as established by the United States Department of Agriculture, will be accepted. The Contractor's suppliers must certify in writing that the stock has actually been grown under Zone 8 or hardier conditions. Plant not so certified will not be accepted.

D. The root system of each plant shall be well provided with fibrous roots. All parts shall be moist and show active green cambium when cut. They shall be sound, healthy and vigorous, well branched and densely foliated when in leaf. They shall be free of disease, insect pests, eggs or larvae.

E. All plants must be moved with the roof systems as solid units with balls of earth firmly wrapped with untreated eight ounce (8 oz.) burlap, firmly held in place by a stout cord or wire. Processed or manufactured plant balls will not be accepted. The diameter and depth of the balls of earth must be sufficient to encompass the fibrous and root feeding system necessary for the healthy development of the plant. No plant will be accepted when the ball of earth surrounding its roots has been badly cracked or broken before or during the process of planting or after the burlap, staves, ropes or platform required in connection with its transplanting have been removed. The plants and balls shall remain intact during all operations. All plants that cannot be planted at once must be heeled in by setting in the ground and covering the balls with soil and watering.

F. The height of the trees (measured from the crown of the roots to the tip of the top branch) shall be not less than a minimum size designated. Take caliper measurements for deciduous trees six inches (6") above ground level up to and including four inches (4") caliper size and twelve inches (12") above ground for larger sizes. Evergreen trees shall be of specified height with spread in proportion to height, as designated in the ASNS Standards, latest edition, and shall be well branched to the ground. The trunk of each tree shall be a single trunk growing from a single unmutilated crown of roots. No part of the trunk shall be conspicuously crooked as compared with normal trees of the same variety. The trunk shall be free from sunscald; frost cracks and wounds resulting from abrasions, fire or other causes. No pruning wounds shall be present having a diameter exceeding two inches (2") and such wounds must show vigorous bark on all edges. Plants shall <u>not</u> be pruned prior to delivery.

G. Groundcover plants, vines, bulbs and perennials shall be of size, age and/or condition listed in the Plant List. Plants shall be healthy, free of insects and diseases. Groundcover plants and vines shall be minimum two (2) year stock, potted or in sod. Perennials shall be potted three (3) year stock and all clumps shall have not less than six (6) buds, eyes or crowns.

H. Container grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together, firm and whole. No plants shall be loose in the container.

I. Plants delivered by truck and plants requiring storage on site shall be properly wrapped and covered to prevent wind-drying and desiccation of branches, leaves or buds; plant balls shall be firmly bound, unbroken, reasonably moist to indicate watering prior to delivery and during storage and tree trunks shall be free from fresh scars and damage in handling. No trees with double-leaders or twin-heads will be acceptable without the written approval of the Landscape Architect. The Contractor shall reject such plants at time of delivery by the nursery/supplier unless such plants were selected by the Landscape Architect as indicated by tags and seals. No plant material from cold storage will be accepted.

J. The Contractor shall be present at the time of delivery of all plants to the site. The Contractor shall remove all tree wrapping at the time of delivery and inspect tree trunks for damage. Damaged plants shall be immediately reported to the Landscape Architect. Trees shall be re-wrapped as part of this Contract after inspection by the Landscape Architect.

2.04 <u>Fertilizer</u>: Fertilizer shall be provided for each plant through the use of slow-release fertilizer certified by the manufacturer to provide controlled release of fertilizer over a minimum of one (1) year period.

Nitrogen	18%

Phosphoric Acid	6%
Potash	12%

Tree Fertilizer: Peter's 20-20-20.

2.05 Staking, Guying and Anchoring Materials:

A. Stakes for supporting trees shall be of sound wood of uniform shape and size, reasonably free of knots, insects and fungi and capable of standing in the ground at least two (2) years. Unless noted otherwise, stakes shall be 2" x 2" nominal size. Stakes shall be stained dark green.

B. Hose to encase wires shall be black, new, two-ply reinforced rubber garden hose, not less than one-half inch (1/2") inside diameter.

C. Cable and Fittings

1. Cable shall be three sixteenths inch (3/16") diameter, seven (7) strand (7 x 19), and galvanized steel cable.

2. Turnbuckles and eyebolts shall be of galvanized steel of size and gauge to provide tensile strength equal to that of the cable. Turnbuckle opening shall be a minimum of three inches (3").

3. Cable clamps shall be malleable compression sleeves of zinc-plated copper. Sleeves shall be of double-barreled configuration for looped connection and sized to match the steel guy or anchor cable.

D. Drive anchors and guy wire assembly shall be as manufactured by Laconia Malleable Iron Works, Laconia, New Hampshire, or "Duckbill" tree anchoring system manufactured by Foresight Industries, Inc., Cheyenne, Wyoming, or "Ground Gripper" anchors as manufactured by A.B. Chance Co., Centralia, MO, or equal. Sizes used shall be in accordance with the manufacturer's specifications and recommendations.

E. Safety flagging for diagonal guy wires shall consist of twelve inch (12") lengths of wooden one by threes, one inch by three inches (1" x 3") nominal dimension, painted with two coats of white enamel paint and fastened to guy wires with screw eyes, galvanized staples or other suitable hardware.

2.06 <u>Mulch</u>:

A. Pine Straw Mulch: Mulch shall be new pine straw mulch. The mulch shall be dark brown in color, free of dirt, mold and extraneous materials.

B. Pine Bark Nuggets: Mulch shall be new pine bark nuggets of medium grade ¼”-1” nugget size range. The mulch shall be dark brown in color, free of dirt, mold and extraneous materials.

2.07 <u>Wrapping Material</u>: Wrapping material shall be first quality, four inch (4") wide heavy waterproof crepe paper manufactured for this purpose. Tape for securing wrapping material shall be a durable, weatherproof tape of same color as wrapping material.

2.08 Water: The Contractor shall be responsible to furnish his/her own supply of water to the site at no extra cost. If possible, the Owner shall furnish the Contractor upon request with an adequate source and supply of water at no charge. However, if the Owner's water supply is not available or not functioning, the Contractor shall be held responsible to furnish adequate supplies at his/her own cost. All work injured or damaged due to the lack of water, or the use of too much water, shall be the Contractor's responsibility to correct. Water shall be free from impurities injurious to vegetation.

PART 3 - EXECUTION

3.01 Planting

A. Furnishing and planting of any plant material includes the digging of the holes, provision of soil additives and loam, furnishing the plants of specified size with roots in the specified manner, the labor of planting, under drains, fertilizing, mulching, guying and staking where called for, and maintenance.

B. Transplanting, as required, shall include the digging and preparation of plants for relocation, the protection and maintenance of plants including temporary heeling-in if required, and the relocation of plants according to all requirements for new planting installations.

1. Plants to be transplanted shall be balled and burlapped or dug using tree spade as part of preparation for transplanting.

2. Ball and burlap operations shall conform to requirements for new plantings except that ball sizes for materials to be transplanted shall, as a minimum, be thirty percent larger than those required by the ANSI Z60.1 standards for comparably sized nursery grown stock.

C. The Contractor shall locate plant material sources and ensure that plants are shipped in timely fashion for installation.

D. Season for Planting: To be established by construction schedule.

E. Plant Material Inspection:

1. At least two weeks prior to the expected planting date, the Contractor shall request that the Landscape Architect provide a representative to select and tag stock to be planted under this Section. The Contractor shall pay for the transportation, subsistence and overnight accommodations, if necessary, for the Landscape Architect's representative during the period of time required to select and tag the plant material.

2. The Contractor shall be responsible for certifying the availability of required plants in specified sizes from his/her sources of supply prior to requesting the Landscape Architect to make plant source inspections. In the event that plants at the inspection location are found to be unavailable or of insufficient size, the Contractor shall be liable to reimburse the Owner for all costs of the Landscape Architect's hourly services, which are, incurred during unproductive inspection trips.

3. Unless specifically designated otherwise, a representative of the Contractor shall accompany the Landscape Architect on all plant material selection field trips.

4. All plants for the project shall be individually tagged for approval with the Landscape Architect's seals, and no plants shall be accepted for delivery to the site without such seals. Representative samples of shrubs and groundcover plants shall be tagged or marked for approval as "An Approved Typical Sample" and shipped to the site.

5. Inspection and approval of plants at the source shall not impair the right of subsequent inspection and rejection upon delivery to the site, or during the progress of the work; if the Landscape Architect finds that plants have declined noticeably due to handling abuse, lack of maintenance, or other causes. Cost of replacements, as required, shall be borne by the Contractor.

F. Planting:

1. Locations for all plants and outlines for planting areas shall be staked on the ground by the Contractor for approval by the Landscape Architect before any plant pits or plant beds are dug.

2. Plant pits shall be excavated with vertical sides. Holes for trees shall be at least two feet (2') greater in diameter than the ball and graded to accommodate root ball and under drains as shown on the drawings. Shrub beds shall be 18". All tree pits dug with a machine shall have the sides of the holes scraped with hand shovels to prevent "scouring" of sides of the holes.

3. All tree pits must drain freely. Contractor shall install under drains as specified entirely around each tree or shrub area found to be retaining water.

4. Planting soil mix as specified shall be prepared and backfilled at individual tree and shrub planting pits as directed.

5. Shrub planting beds shall be excavated and backfilled with planting soil mix to a minimum uniform depth of 18" below final grade, or as shown on the drawings.

6. All plant roots and earth balls must be damp and thoroughly protected from sun and wind from the beginning of the digging operation, during transportation and on the ground until the final planting. The plants shall be planted in the center of the holes and at the same depth as they previously grew except for plants planted in clay soils, which shall be planted slightly high as shown on drawings. After completion of planting installations, remove burlap, rope, wires, etc., from the upper quarter of the root balls. Do not pull burlap or wires out from the sides or under root balls. Planting soil mix shall be backfilled in layers of not more than six inches (6") and each layer watered sufficiently to settle before the next layer is put in place. Enough planting soil mix shall be used to bring the surface to finished grade when settled. A saucer shall be formed around each plant at a depth of six inches (6") for trees.

7. At the time of planting, install fertilizer at a depth of six (6) inches equally spread around the plant, as it is being backfilled. The application rates for fertilizer:

<u>Type of Plant</u>	<u>Rate</u>

Deciduous Shade Trees	18 lbs./1000 S.F.
Evergreen/ Small Flowering Trees	10 lbs./1000 S.F.
Shrubs	8 lbs./1000 S.F.

G. All plants shall be watered immediately following planting and thereafter shall be inspected frequently for watering needs and watered, as required, to provide adequate moisture in the planting pit.

H. All trees shall be firmly staked, guyed or anchored at the time of planting, unless otherwise approved or directed by the Landscape Architect. Stakes shall be of even height, plumb and neat in appearance and they shall not injure plant balls. Wires and cables used for tying the trunk to stakes or for guying shall be secured to the tree by passing through an approved hose to prevent chafing and injury to the trees.

Cable ends shall be formed with a looped connection, which is secured with compressed malleable fittings as specified.

I. Mulch material shall be placed over entire surface areas of individual trees and shrubs and over the entire area of planting beds to a depth of two inches (3") after settlement, not later than one (1) week after planting. No mulch shall be applied prior to the first watering of plant materials.

J. The trunks of all deciduous trees over one and one-half inches (1-1/2") in diameter shall be wrapped after planting and after inspection of tree trunks by the Architect. Wrapping shall extend from the ground line to the height of the second branches or to the height directed. The specified wrapping shall be wound spirally, starting from the base and overlapping one and one half inches (1-1/2"). Wrapping shall be securely taped to prevent loosening and unraveling.

K. Pruning:

1. Each plant shall be pruned in accordance with the workmanship requirements of "Pruning Standards" to preserve the natural character of the plant.

2. Tree pruning shall be undertaken to the full height of affected trees.

3. All dead wood or suckers and all broken or badly bruised branches shall be removed. In addition, up to one-fourth (1/4) of the wood shall be removed by thinning out and shortening branches to balance root loss due to re-transplanting. Never cut a leader.

L. If planting is done after lawn preparation or installation, proper protection of lawn areas shall be provided and any damage resulting from planting operations shall be repaired immediately at no cost to the Owner.

M. In the event that rock or underground construction work or obstructions are encountered in any plant pit or bed excavation work to be done under this Contract, alternate locations may be selected by the Landscape Architect.

3.02 <u>Maintenance</u>

A. Maintenance shall begin immediately after each plant is planted and shall continue for a minimum of thirty days following the completion of all planting installations, and until provisional acceptance of the planting work by the Landscape Architect, as defined under Substantial Completion.

B. Maintenance shall consist of keeping the plants in a healthy growing condition and shall include but is not limited to watering, weeding, cultivating, re-mulching, tightening and repairing of guys, removal of deal material, resetting plants to proper grades or upright position, and maintaining the planting saucer.

1. Plants shall be inspected for watering needs at least twice each week and watered as necessary to promote plant growth and vitality.

2. Stakes shall be kept plumb and neat in appearance. Guys, wires and anchoring cables shall be tightened and repaired weekly.

3. Planting beds and individual plant pits shall be kept free of weeds, and mulch shall be replaced as required to maintain the specified layer of mulch. Beds and individual pits shall be neat in appearance and maintained to the designed layout.

4. Plants that die during the maintenance period shall be removed and replaced at once, unless designated otherwise by the Landscape Architect.

5. Spraying for both insect pests and diseases shall be included during the maintenance period as required and as directed.

C. During the maintenance period, any decline in the condition of plantings shall require the Contractor to take immediate action to identify potential problems and undertake corrective measures. If required, the Contractor shall engage professional arborists and/or horticulturalists to inspect plant materials and to identify problems and recommend corrective procedures.

3.03 Acceptance

A. Following a minimum thirty day maintenance period after the completion of all planting installations, the Contractor shall request the Landscape Architect in writing for a formal inspection of the planting work.

B. If plant materials and workmanship are acceptable, written notice will be given by the Landscape Architect to the Contractor stating that the work has received provisional acceptance, subject to maintenance requirements noted herein, and that the guarantee period has commenced from the date of provisional acceptance.

C. If a number of plants are sickly or dead at the time of inspection, or if in the Landscape Architect's opinion, workmanship is unacceptable, written notice will be given by the Landscape Architect to the Contractor in the form of a punch list, which itemizes necessary planting replacements and/or other deficiencies to be remedied. The Contractor's responsibility for maintenance of all plants shall be extended until replacements acre made or other deficiencies are corrected. All dead and unsatisfactory plants shall be removed promptly from the project. Replacements shall conform in all respects to the Specifications for new plants and shall be planted in the same manner.

D. Acceptance of the planting work shall be established by the Landscape Architect in writing, following the completion of all maintenance work requirements as specified herein, and following the correction of all punch list deficiencies by the Contractor.

3.04 Guarantee

A. Plants shall be guaranteed for a period of ninety (90) days after written notification of acceptance and shall be alive and in satisfactory growth at the end of the guarantee period.

B. At the end of the guarantee period, a final inspection will be held to determine whether any plant material replacements are required. Each plant shall show at least 75% healthy growth and shall have the natural character of its species as determined by the Landscape Architect. Plants found unacceptable shall be removed promptly from the site and replaced during the normal planting season, until the plants live through one year. A final inspection for acceptance will be made after the replacement plantings have lived through the first ninety (90) days.

C. All replacements shall be plants of the same kind and size specified in the Plant List. The cost shall be borne by the Contractor, except for possible replacements due to vandalism or neglect on the part of others.

END OF SECTION

SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.01 References

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

B. Examine all drawings and all other sections of the Specifications for requirements therein affecting the work of this trade.

1.02 Scope: The work of this Section consists of all lawn work, fine grading and related items as indicated on the drawings and/or as specified herein and includes, but is not limited to, the following:

A. Fine grading and loaming.
B. Sodding.
C. Maintenance and protection.

1.03 Related Work Under Other Sections: The following items of related work are specified and included in other sections of the Specifications:

A. Site clearing and preparation.
B. Earthwork.
C. Planting Irrigation.
D. Planting.

1.04 Definitions: The following related items are included herein and shall mean:

AOAC: Association of Official Agricultural Chemists.

1.05 Samples and Submittals: At least thirty days prior to intended use, the Contractor shall provide the following samples and submittals for approval. Do not order materials until Architect's approval of samples, certifications or test results has been obtained. Delivered materials shall closely match the approved samples.

A. Loam Soil: The Contractor shall provide a one (1) cubic foot representative sample from each proposed source for testing, analysis, and approval. Contractor shall deliver samples to testing laboratories and shall have the testing report sent directly to the Landscape Architect and pay all costs. Testing reports shall include the following tests and recommendations.

1. Mechanical gradation (sieve analysis) for loam shall be performed and compared to the USDA Soil Classification System.

2. Loam soils provide mechanical gradation (sieve analysis, Atteberg limits, liquid limit and plastic limits.

3. Percent of organics for loam soils shall be determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F., plus or minus 9 degrees.

4. Chemical analysis for loam soils shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Soluble Salts, and acidity (pH).

5. Tests for gradation shall be performed by a private testing laboratory approved by the Owner's representative. Tests for soil chemistry and pH may be performed by a public extension service agency or approved private laboratory.

6. Soil analysis tests shall show recommendations for soil additives to correct soils deficiencies as necessary, and for fertilizing and limiting applications to support successful turf growth.

7. All tests shall be performed in accordance with the current standards of the Association of Official Agriculture Chemists.

B. Sod: Provide supplier's name, address, and phone number.

C. Fertilizer: Submit four (4) certificates of analysis for lawn fertilizer.

D. Maintenance manual for lawn maintenance: Three (3) copies.

1.06 Examination of Conditions: All areas to be fine graded and seeded or sodded shall be inspected by the Contractor before starting work. Any defects such as incorrect grading, etc., shall be reported to the Owner's representative prior to beginning this work. The commencement of work by the Contractor shall indicate his acceptance of the areas to be fine graded, and he shall assume full responsibility for the work of this Section.

PART 2 - PRODUCTS

2.01 Loam Soil

A. Loam for all lawn areas indicated on the drawings shall be a "fine sandy loam" or a "sandy loam" determined by mechanical analysis and based on the "USDA Classification System". It shall be of uniform composition, without admixture of subsoil. It shall be free of stones greater than two inches (2"), lumps, plants and their roots, debris and other extraneous matter as determined by the Landscape Architect. It shall be obtained from naturally well-drained areas, which have never been stripped before and have a history of satisfactory vegetative growth.

B. Loam shall have an acidity range of pH 5.6 to pH 6.5 and shall contain not less than 4% nor more than 12% organic matter, as certified by required tests.

C. All loam proposed for use shall be tested for conformance to the specifications.

2.02 Soil Additives

A. Commercial fertilizer or other additives shall be used to counteract soil deficiencies as recommended by the soil test analysis, and as specified seeding supplements.

B. Commercial fertilizer shall be a product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers, which shall bear the manufacturer's certificate of compliance covering analysis, which shall be furnished to the Owner's representative. At least 50% by weight of the nitrogen content shall be derived from organic materials. Fertilizer shall contain not less than the percentages of weight of ingredients as follows or as recommended by the soil analysis:

Nitrogen	Phosphorus	Potash
12%	4%	8%

C. Limestone: Ground limestone shall be an approved agricultural limestone containing not less than 85% of total calcium or magnesium carbonates. Limestone shall be ground to such fineness that 50% will pass a 100-mesh sieve and 95% will pass through a 20-mesh sieve.

D. Sulphur shall be commercial or flour sulphur, unadulterated, and shall be delivered in containers with the name of the manufacturer, material, analysis and net weight appearing on each container.

E. Superphosphate: Superphosphate shall be composed of finely ground phosphate rock as commonly used for agricultural purposes containing not less than 18% available phosphoric acid.

2.03 Sod

A. Two years old nursery-grown sod, Zoysia ‘Zeon’ grass sod.

B. Sod shall be dense, healthy, field-grown on fumigated soil with the grass having been mowed at 1 inch height before lifting from field.

C. Sod shall be dark green in color, relatively free of thatch, free from diseases and harmful insects.

D. Sod shall be reasonably free of objectionable grassy and broadleaf weeds. Sod shall be considered weed free if no more than one such weed is found per 100 sq. ft. of sod.

E. Sod shall be rejected if found to contain the following weeds: common bermudagrass, quackgrass, johnsongrass, poison ivy, nimbleweed, thistle, bindweed, bentgrass, perennial sorrel, wiregrass, and nutsedge.

2.04 Fertilizers

A. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers, which shall bear the manufacturer's certificate of compliance covering analysis. At least 50% by weight of the nitrogen content shall be derived from organic materials. Fertilizer shall contain not less than the percentages of weight of ingredients as follows or as recommended by the soil analysis:

Nitrogen	Phosphorus	Potash
12%	4%	8%

B. Superphosphate shall be composed of finely ground phosphate rock as commonly used for agricultural purposes containing not less than 18% available phosphoric acid.

2.05 Chemicals and Insecticides: Provide chemicals and insecticides as needed for fungus, disease or pest control. Selected materials shall be specified for the identified problem and shall be applied according to manufacturer's recommended rates.

2.06 Water: The Contractor shall be responsible to furnish his own supply of water to the site at no extra cost. If possible, the Owner shall furnish the Contractor upon request with an adequate source and supply of water at no charge. However, if the Owner's water supply is not available or not functioning, the Contractor

shall be held responsible to furnish adequate supplies at his own cost. All work injured or damaged due to the lack of water or the use of too much water shall be the Contractor's responsibility to correct. Water shall be free from impurities injurious to vegetation.

PART 3 - EXECUTION

3.01 Fine Grading and Loam Establishment

A. A minimum of four inches (4") of loam shall be placed or exist in all areas to be planted. Existing soil may be used with appropriate adjustment to meet specifications.

B. Loam shall be placed and spread over approved areas to a depth sufficiently greater than four inches (4") so that after natural settlement and light rolling, a minimum of four inch (4") compacted loam depth will have been provided and the completed work will conform to the lines, grades and elevations indicated. Supply additional loam, after testing and approval, as may be needed to give the specified depths and finished grades under the contract without additional cost to the Owner.

C. No subsoil or loam shall be handled in any way if it is in a wet or frozen condition.

D. After loam has been spread, it shall be carefully prepared by scarifying or harrowing and hand raking. Remove all large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter. Remove all stones over one inch (1") in diameter from the top three inches (3") of the loam bed. Loam shall also be free of small stones in excessive quantities as determined by the Owner's representative or Architect.

E. The whole surface shall then be compacted with a roller or other suitable means to achieve a maximum dry density of 88 to 90 percent for the placed loam as determined by ASTM D698. During the compaction process, all depressions caused by settlement or rolling shall be filled with additional loam and the surface shall be regraded and rolled until presenting a smooth and even finish corresponding to the required grades.

F. Incorporation of Additives: Soil additives shall be spread and thoroughly incorporated into the layer of loam soil by harrowing or other methods approved by the Landscape Architect. The following soil additives shall be incorporated:
    1. Ground limestone as required by soil analysis to achieve a pH of 6.0 to 6.5, but the maximum amount applied shall be one (1) pound per square yard.

    2. Fertilizer at the rate of twenty (20) lbs. minimum per one thousand (1,000) square feet, or more, as recommended by the soil analysis.

3. Superphosphate at the rate of twenty (20) lbs. per one thousand (1,000) square feet.

Following the incorporation of additives, the surface shall be recompacted as required to meet the standards outlined above.

G. Contractor shall obtain Landscape Architect's written approval of fine grading and bed preparation before doing any sprigging.

H. The season for lawn work shall be from May 15 to August 15. The actual lawn construction shall be done, however, only during periods within this season, which are normal for such work as determined by weather conditions and by accepted practice in this locality. At his option, and on his own responsibility, the Contractor may proceed under unseasonable conditions without additional compensation, but subject to Landscape Architect's approval of time and methods; or install a cool season annual turf grass as a temporary measure until time to establish permanent turf grass occurs.

3.02 Sodded Lawn

A. Sod Bed Preparation

1. Rolling: Roll topsoil with 200-pound roller.

2. Moistening: After all unevenness in the soil surface has been corrected, lightly moisten the soil immediately prior to laying the sod.

3. Timing: All turf grass areas to be sod planted May-August.

B. Sodding Operation:

1. Starter Strip: Lay the first row of sod in a straight line, with subsequent rows parallel to and tightly against each other, with no spaces between strips. Stagger lateral joints. Do not stretch or overlap sod. Butt all joints tightly to eliminate all voids. Use a sharp edged tool to cut sod and shape curves.

2. Rolling: Thoroughly roll the sod to make contact with sod bed. Roll the entire section of completed sod in two perpendicular directions.

3. Watering: Thoroughly water sod immediately after installation enough to wet the underside of the new sod pad and the soil immediately below to a depth of 6 inches.

4. Top-Dress Fertilizer: Apply 12-4-8 turf grade fertilizer at the rate of 10 pounds per 1,000 square feet immediately after rolling and before irrigation, and again in 21 days after sodding.

3.03 Lawn Maintenance

A. Maintenance shall begin immediately after any area is sodded or sprigged and shall continue for a minimum sixty (60) day active growing period.

B. Maintenance shall include repairing, mowing, watering, weeding, fertilizing, resetting and straightening of protective barriers. Lawn work maintenance shall also include chemical treatments as required for fungus and/or pest control.

C. Watering:

1. The Contractor shall provide all labor and arrange for all watering necessary to establish an acceptable lawn. In the absence of adequate irrigation or rainfall, watering shall be performed daily or as often as necessary to maintain moist soil to a depth of at least two inches (2") for seeded areas.

2. Watering shall be done in a manner which will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to apply one (1) complete coverage to the lawn areas in an eight (8) hour period.

D. After the grass in sodded or sprigged areas has appeared, all areas and parts of areas which, in the opinion of the Landscape Architect, fail to show a uniform stand of grass, for any reason whatsoever, shall be repaired and such areas and parts of areas shall be repaired repeatedly until all areas are covered with satisfactory growth of grass. Resprigging together with necessary grading, fertilizing, and trimming shall be done at the expense of the Contractor.

E. Mowing and Edging:

1. The Contractor shall keep lawn areas mowed until acceptance of the Contract by cutting to a height of two inches (2").

2. At each mowing, all edges of walks, drives, plant beds and other border conditions shall be edge trimmed by hand or machine to produce straight and uniform edge conditions.

3. Remove and discard clippings and debris generated by each mowing and edging operation.

3.04 <u>Acceptance Standards for Lawns</u>

A. Following the minimum required maintenance periods for lawn construction, the Contractor shall request the Landscape Architect in writing for a formal inspection of the completed work.

B. Acceptance Requirements:

1. Sodded or sprigged areas shall have a close stand of grass with no weeds present and no bare spots greater than 6 inches (6") in diameter over greater than five percent (5%) of the overall seeded area. At least 90% of the grass established shall be permanent grass species.

2. At the time of acceptance, the Contractor shall remove temporary barriers sued to protect lawn areas.

C. Furnish three (3) copies full and complete written instructions for maintenance of the lawns to the Owner at the time of acceptance in conformance with submittals requirements.

3.05 Clean Up: Absolutely no debris may be left on the site. Excavated material shall be removed as directed. Repair any damage to site or structures to restore them to their original condition, as directed by the Architect, at no cost to the Owner.

END OF SECTION

SECTION 32 92 19

SEEDING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 602	(1995a) Agricultural Liming Materials
ASTM D 2028	(1976; R 1997) Cutback Asphalt (Rapid-Curing Type)
ASTM D 4972	(1995a) pH of Soils
ASTM D 5268	(1992; R 1996) Topsoil Used for Landscaping Purposes
ASTM D 977	(1998) Emulsified Asphalt

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act	(1995) Federal Seed Act Regulations Part 201

1.2 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Product Data

Equipment;
Surface Erosion Control Material;
Chemical Treatment Material;

Manufacturer's literature including physical characteristics, application and installation instructions for equipment, surface erosion control material and chemical treatment material.

A listing of equipment to be used for the seeding operation.

Delivery;

Delivery schedule.

Finished Grade and Topsoil;

Finished grade status.

Topsoil;

Availability of topsoil from the stripping and stock piling operation.

Quantity Check;

Bag count or bulk weight measurements of material used compared with area covered to determine the application rate and quantity installed.

Seed Establishment Period;

Calendar time period for the seed establishment period. When there is more than one seed establishment period, the boundaries of the seeded area covered for each period shall be described.

Maintenance Record;

Maintenance work performed, area repaired or reinstalled, diagnosis for unsatisfactory stand of grass plants.

Samples

Delivered Topsoil;

Samples taken from several locations at the source.

Soil Amendments;

A 10 pound sample.

Mulch;

A 10 pound sample.

Test Reports

Equipment Calibration;

Certification of calibration tests conducted on the equipment used in the seeding operation.

Soil Test;

Certified reports of inspections and laboratory tests, prepared by an independent testing agency, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used and compliance with recognized test standards shall be described.

Certificates

Seed;

Topsoil;
pH Adjuster;
Fertilizer;
Organic Material;
Soil Conditioner;
Mulch;
Asphalt Adhesive;

Prior to the delivery of materials, certificates of compliance attesting that materials meet the specified requirements. Certified copies of the material certificates shall include the following:

a. Seed. Classification, botanical name, common name, percent pure live seed, minimum percent germination and hard seed, maximum percent weed seed content, and date tested.

b. Topsoil. Particle size, pH, organic matter content, textural class, soluble salts, chemical and mechanical analyses.

c. pH Adjuster. Calcium carbonate equivalent and sieve analysis.

d. Fertilizer. Chemical analysis and composition percent.

e. Organic Material: Composition and source.

f. Soil Conditioner: Composition and source.

g. Mulch: Composition and source.

h. Asphalt Adhesive: Composition.

1.3 SOURCE INSPECTION

The source of delivered topsoil shall be subject to inspection.

1.4 DELIVERY, INSPECTION, STORAGE, AND HANDLING

1.4.1 Delivery

A delivery schedule shall be provided at least 10 calendar days prior to the first day of delivery.

1.4.1.1 Delivered Topsoil

Prior to the delivery of any topsoil, its availability shall be verified in paragraph TOPSOIL. A soil test shall be provided for topsoil delivered to the site.

1.4.1.2 Soil Amendments

Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.

1.4.2 Inspection

Seed shall be inspected upon arrival at the job site for conformity to species and quality. Seed that is wet, moldy, or bears a test date five months or older, shall be rejected. Other materials shall be inspected for compliance with specified requirements. The following shall be rejected: open soil amendment containers or wet soil amendments; topsoil that contains slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 1-1/2 inch diameter; and topsoil that contains viable plants and plant parts. Unacceptable materials shall be removed from the job site.

1.4.3 Storage

Materials shall be stored in designated areas. Seed, lime, and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment material shall be stored according to manufacturer's instructions and not with seeding operation materials.

1.4.4 Handling

Except for bulk deliveries, materials shall not be dropped or dumped from vehicles.

1.4.5 Time Limitation

Hydroseeding time limitation for holding seed in the slurry shall be a maximum 24 hours.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Seed Classification

State-certified seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for percentages of mixture, purity, germination, hard seed, weed seed content, and inert material. Labels shall be in conformance with AMS Seed Act and applicable state seed laws.

2.1.2 Composition

Name of Grass or Legume Botanical and Common

Seed	Min. Percent Pure Seed	Min. Percent Germination and Hard Seed	Max. Percent Weed Seed
Bermuda	82.45	85	1
Annual Rye	88	85	0.5
German Millett	83	85	0.5
Sericea Lespedeza	88	85	1

2.1.3 Seed Mixture

Planting Season	Variety	Rate (lb/acre)
Spring/Summer	Common Bermuda, hulled	25
	German Millet	10
Fall/Winter	Annual Rye	40
	Common Bermuda, unhulled	30

Proportion seed mixtures by weight. Seeding during Season 3 is for temporary ground cover which must later be replaced by Season 1 plantings for a permanent stand of grass. The same requirements for turf establishment apply for Season 1 as for Season 3.

2.1.4 Quality

Weed seed shall be a maximum 1 percent by weight of the total mixture.

2.1.5 Seed Mixing

The mixing of seed may be done by the seed supplier prior to delivery, or on site as directed.

2.1.6 Substitutions

Substitutions will not be allowed without written request and approval from the Engineer.

2.2 TOPSOIL

Topsoil shall be as defined in ASTM D 5268. When available, the topsoil shall be the existing surface soil stripped and stockpiled onsite in accordance with Section 02300 EARTHWORK. When additional topsoil is required beyond the available topsoil from the stripping operation, topsoil shall be delivered and amended as recommended by the soil test for the seed specified at no additional cost to the Owner. Topsoil shall be free from slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 1-1/2 inch diameter. Topsoil shall be free from viable plants and plant parts.

2.3 SOIL AMENDMENTS

Soil amendments shall consist of pH adjuster, fertilizer, organic material and soil conditioners meeting the following requirements. Vermiculite shall not be used.

2.3.1 pH Adjuster

The pH adjuster shall be an agricultural liming material in accordance with ASTM C 602. The materials shall be hydrated lime. The pH adjuster shall be used to create a favorable soil pH for the plant material specified. Contractor shall perform soil test and apply lime at the recommended rate. The results of the test will be provided to the Engineer.

2.3.1.1 Hydrated Lime

Hydrated lime shall contain a minimum calcium carbonate equivalent of 110 percent. Gradation: A minimum 100 percent shall pass through a No. 8 sieve and a minimum 97 percent shall pass through a No. 60 sieve.

2.3.2 Fertilizer

It shall be as recommended by the soil test. Fertilizer shall be controlled release commercial grade, free flowing, uniform in composition, and consist of a nitrogen-phosphorus-potassium ratio. The fertilizer shall be derived from sulphur coated urea, urea formaldehyde, plastic or polymer coated pills, or isobutylenediurea (IBDU). Fertilizer shall be balanced with the inclusion of trace minerals and micro-nutrients. Contractor shall perform soil test and apply fertilizer at the recommended rate. The results of the test will be provided to the Engineer.

2.3.3 Nitrogen Carrier Fertilizer

It shall be as recommended by the soil test. Nitrogen carrier fertilizer shall be commercial grade, free flowing, and uniform in composition. The fertilizer may be a liquid nitrogen solution.

2.4 MULCH

Mulch shall be free from weeds, mold, and other deleterious materials. Mulch materials shall be native to the region.

2.4.1 Straw

Straw shall be stalks from oats, wheat, rye, barley, or rice, furnished in air-dry condition and with a consistency for placing with commercial mulch-blowing equipment.

2.4.2 Hay

Hay shall be native hay, sudan-grass hay, broomsedge hay, or other herbaceous mowings, furnished in an air-dry condition suitable for placing with commercial mulch-blowing equipment.

2.4.3 Wood Cellulose Fiber

Wood cellulose fiber shall not contain any growth or germination-inhibiting factors and shall be dyed an appropriate color to facilitate placement during application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 4.5 to 6.0.

2.5 ASPHALT ADHESIVE

Asphalt adhesive shall conform to the following: Emulsified asphalt, conforming to ASTM D 977, Grade SS-1; and cutback asphalt, conforming to ASTM D 2028, Designation RC-70.

2.6 WATER

Water shall be the responsibility of the Contractor, unless otherwise noted. Water shall not contain elements toxic to plant life.

2.7 SURFACE EROSION CONTROL MATERIAL

Surface erosion control material shall conform to the following:

2.7.1 Surface Erosion Control Blanket

Blanket shall be machine produced mat of wood excelsior formed from a web of interlocking wood fibers; covered on one side with either knitted straw blanket-like mat construction; covered with biodegradable plastic mesh; or interwoven biodegradable thread, plastic netting, or twisted kraft paper cord netting.

2.7.2 Surface Erosion Control Fabric

Fabric shall be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips shall have a minimum life of 6 months.

2.7.3 Surface Erosion Control Net

Net shall be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately 1 inch square.

2.7.4 Erosion Control Material Anchors

Erosion control anchors shall be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 INSTALLING SEED TIME AND CONDITIONS

3.1.1 Seeding Time

Seed shall be installed from April 15 to July 15 for warm season spring establishment; and from August 15 to September 15 for cool season fall establishment.

3.1.2 Seeding Conditions

Seeding operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to the seeding operations, proposed alternate times shall be submitted for approval.

3.1.3 Equipment Calibration

Immediately prior to the commencement of seeding operations, calibration tests shall be conducted on the equipment to be used. These tests shall confirm that the equipment is operating within the manufacturer's specifications and will meet the specified criteria. The equipment shall be calibrated a minimum of once every day during the operation. The calibration test results shall be provided within 1 week of testing.

3.1.4 Soil Test

Delivered topsoil, existing soil in smooth graded areas, and stockpiled topsoil shall be tested in accordance with ASTM D 5268 and ASTM D 4972 for determining the particle size, pH, organic matter content, textural class, chemical analysis, soluble salts analysis, and mechanical analysis. Sample collection on site shall be random over the entire site. Sample collection for stockpiled topsoil shall be at different levels in the stockpile. The soil shall be free from debris, noxious weeds, toxic substances, or other materials harmful to plant growth. The test shall determine the quantities and type of soil amendments required to meet local growing conditions for the seed species specified.

3.2 SITE PREPARATION

3.2.1 Finished Grade and Topsoil

The Contractor shall verify that finished grades are as indicated on drawings, and the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 02300 EARTHWORK, prior to the commencement of the seeding operation.

3.2.2 Application of Soil Amendments

3.2.2.1 Applying pH Adjuster

The pH adjuster shall be applied as recommended by the soil test. The pH adjuster shall be incorporated into the soil to a maximum 4 inch depth or may be incorporated as part of the tillage operation.

3.2.2.2 Applying Fertilizer

The fertilizer shall be applied as recommended by the soil test. Fertilizer shall be incorporated into the soil to a maximum 4 inch depth or may be incorporated as part of the tillage or hydroseeding operation.

3.2.3 Tillage

Soil on slopes up to a maximum 3-horizontal-to-1-vertical shall be tilled to a minimum 4 inch depth. On slopes between 3-horizontal-to-1-vertical and 1-horizontal-to-1 vertical, the soil shall be tilled to a minimum 2 inch depth by scarifying with heavy rakes, or other method. Rototillers shall be used where soil conditions and length of slope permit. On slopes 1-horizontal-to-1 vertical and steeper, no tillage is required. Drainage patterns shall be maintained as indicated on drawings. Areas compacted by construction operations shall be completely pulverized by tillage. Soil used for repair of surface erosion or grade deficiencies shall conform to topsoil requirements. The pH adjuster, fertilizer, and soil conditioner may be applied during this procedure.

3.2.4 Prepared Surface

3.2.4.1 Preparation

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove debris.

3.2.4.2 Lawn Area Debris

Debris and stones over a minimum 5/8 inch in any dimension shall be removed from the surface.

3.2.4.3 Field Area Debris

Debris and stones over a minimum 3 inch in any dimension shall be removed from the surface.

3.2.4.4 Protection

Areas with the prepared surface shall be protected from compaction or damage by vehicular or pedestrian traffic and surface erosion.

3.3 INSTALLATION

Prior to installing seed, any previously prepared surface compacted or damaged shall be reworked to meet the requirements of paragraph SITE PREPARATION. Seeding operations shall not take place when the wind velocity will prevent uniform seed distribution.

3.3.1 Installing Seed

Seeding method shall be Drill Seeding or Hydroseeding. Seeding procedure shall ensure even coverage. Gravity feed applicators, which drop seed directly from a hopper onto the prepared soil, shall not be used because of the difficulty in achieving even coverage, unless otherwise approved. Absorbent polymer powder shall be mixed with the dry seed at the rate recommended by the manufacturer.

3.3.1.1 Drill Seeding

Seed shall be uniformly drilled to a maximum 1/2 inch depth and at the rate of 1000 pounds per acre, using equipment having drills a maximum 7 inches distance apart. Row markers shall be used with the drill seeder. Half the total rate of seed application shall be drilled in 1 direction, with the remainder of the seed rate drilled at 90 degrees from the first direction. The drilling equipment shall be maintained with half full seed boxes during the seeding operations.

3.3.1.2 Rolling

The entire area shall be firmed with a roller not exceeding 90 pounds per foot roller width. Slopes over a maximum 3-horizontal-to-1 vertical shall not be rolled. Areas seeded with seed drills equipped with rollers shall not be rolled.

3.3.2 Hydroseeding

Seed shall be mixed to ensure broadcast at the rate of 1000 pounds per acre. Seed and fertilizer shall be added to water and thoroughly mixed to meet the rates specified. The time period for the seed to be held in the slurry shall be a maximum 24 hours. Wood cellulose fiber mulch and tackifier shall be added at the rates recommended by the manufacturer after the seed, fertilizer, and water have been thoroughly mixed to produce a homogeneous slurry. Slurry shall be uniformly applied under pressure over the entire area. The hydroseeded area shall not be rolled.

3.3.3 Mulching

3.3.3.1 Hay or Straw Mulch

Hay or straw mulch shall be spread uniformly at the rate of 2 tons per acre. Mulch shall be spread by hand, blower-type mulch spreader, or other approved method. Mulching shall be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch shall not be bunched or clumped. Sunlight shall not be completely excluded from penetrating to the ground surface. All areas installed with seed shall be mulched on the same day as the seeding. Mulch shall be anchored immediately following spreading.

3.3.3.2 Mechanical Anchor

Mechanical anchor shall be a V-type-wheel land packer; a scalloped-disk land packer designed to force mulch into the soil surface; or other suitable equipment.

3.3.3.3 Asphalt Adhesive Tackifier

Asphalt adhesive tackifier shall be sprayed at a rate between 10 to 13 gallons per 1000 square feet. Sunlight shall not be completely excluded from penetrating to the ground surface.

3.3.3.4 Asphalt Adhesive Coated Mulch

Hay or straw mulch may be spread simultaneously with asphalt adhesive applied at a rate between 10 to 13 gallons per 1000 square feet, using power mulch equipment that shall be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch shall be applied evenly over the surface. Sunlight shall not be completely excluded from penetrating to the ground surface.

3.3.3.5 Wood Cellulose Fiber, Paper Fiber, and Recycled Paper

Wood cellulose fiber, paper fiber, or recycled paper shall be applied as part of the hydroseeding operation. The mulch shall be mixed and applied in accordance with the manufacturer's recommendations.

3.3.4 Watering Seed

Watering shall be started immediately after completing the seeding of an area. Water shall be applied to supplement rainfall at a rate sufficient to ensure moist soil conditions to a minimum 1 inch depth. Run-off and puddling shall be prevented. Watering trucks shall not be driven over turf areas, unless otherwise directed. Watering of other adjacent areas or plant material shall be prevented.

3.4 SURFACE EROSION CONTROL

3.4.1 Surface Erosion Control Material

Where indicated or as directed, surface erosion control material shall be installed in accordance with manufacturer's instructions. Placement of the material shall be accomplished without damage to installed material or without deviation to finished grade.

3.4.2 Temporary Seeding

When directed during contract delays affecting the seeding operation or when a quick cover is required to prevent surface erosion, the areas designated shall be seeded in accordance with temporary seed species listed under Paragraph SEED.

3.4.2.1 Soil Amendments

When soil amendments have not been applied to the area, the quantity of 1/2 of the required soil amendments shall be applied and the area tilled in accordance with paragraph SITE PREPARATION. The area shall be watered in accordance with paragraph Watering Seed.

3.4.2.2 Remaining Soil Amendments

The remaining soil amendments shall be applied in accordance with the paragraph Tillage when the surface is prepared for installing seed.

3.5 QUANTITY CHECK

For materials provided in bags, the empty bags shall be retained for recording the amount used. For materials provided in bulk, the weight certificates shall be retained as a record of the amount used. The amount of material used shall be compared with the total area covered to determine the rate of application used. Differences between the quantity applied and the quantity specified shall be adjusted as directed.

3.6 RESTORATION AND CLEAN UP

3.6.1 Restoration

Existing turf areas, pavements, and facilities that have been damaged from the seeding operation shall be restored to original condition at Contractor's expense.

3.6.2 Clean Up

Excess and waste material shall be removed from the seeded areas and shall be disposed offsite. Adjacent paved areas shall be cleaned.

3.7 PROTECTION OF INSTALLED AREAS

Immediately upon completion of the seeding operation in an area, the area shall be protected against traffic or other use by erecting barricades and providing signage as required, or as directed. Signage shall be in accordance with Section 10430 EXTERIOR SIGNAGE.

3.8 SEED ESTABLISHMENT PERIOD

3.8.1 Commencement

The seed establishment period to obtain a healthy stand of grass plants shall begin on the first day of seeding work under this contract and shall continue through the remaining life of the contract and end 12 months after the last day of the seeding operation required by this contract. Written calendar time period shall be furnished for the seed establishment period. When there is more than 1 seed establishment period, the boundaries of the seeded area covered for each period shall be described. The seed establishment period shall be modified for inclement weather, shut down periods, or for separate completion dates of areas.

3.8.2 Satisfactory Stand of Grass Plants

Grass plants shall be evaluated for species and health when the grass plants are a minimum 1 inch high.

3.8.2.1 Lawn Area

A satisfactory stand of grass plants from the seeding operation for a lawn area shall be a minimum 100 grass plants per square foot. Bare spots shall be a maximum 6 inches square. The total bare spots shall be a maximum 2 percent of the total seeded area.

3.8.2.2 Field Area

A satisfactory stand of grass plants from the seeding operation for a field area shall be a minimum 100 grass plants per square foot. The total bare spots shall not exceed 2 percent of the total seeded area.

3.8.3 Maintenance During Establishment Period

Maintenance of the seeded areas shall include eradicating weeds, insects and diseases; protecting embankments and ditches from surface erosion; maintaining erosion control materials and mulch; protecting installed areas from traffic; mowing; watering; and post-fertilization.

3.8.3.1 Mowing

a. Lawn Areas: Lawn areas shall be mowed to a minimum 3 inch height when the turf is a maximum 4 inches high. Clippings shall be removed when the amount cut prevents sunlight from reaching the ground surface.

b. Field Areas: Field areas shall be mowed once during the season to a minimum 3 inch height. Clippings shall be removed when the amount cut prevents sunlight from reaching the ground surface.

3.8.3.2 Post-Fertilization

The fertilizer shall be applied as recommended by the soil test. A maximum 1/2-pound per 1000 square feet of actual available nitrogen shall be provided to the grass plants. The application shall be timed prior to the advent of winter dormancy and shall be made without burning the installed grass plants.

3.8.3.3 Repair or Reinstall

Unsatisfactory stand of grass plants and mulch shall be repaired or reinstalled, and eroded areas shall be repaired in accordance with paragraph SITE PREPARATION.

3.8.3.4 Maintenance Record

A record of each site visit shall be furnished, describing the maintenance work performed; areas repaired or reinstalled; and diagnosis for unsatisfactory stand of grass plants.

PART 4 PAYMENT

Payment for erosion control measures shall be included in the unit price of the utility.

-- End of Section --

SECTION 33 11 00
WATER DISTRIBUTION

HARNETT REGIONAL WATER STANDARD SPECIFICATIONS FOR WATER DISTRIBUTION

CHAPTER 9

WATER SYSTEM STANDARDS AND SPECIFICATIONS

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CHAPTER 9 WATER SYSTEM STANDARDS AND SPECIFICATIONS

Section 9.1 Design of Water System Improvements

All line extensions and improvements to the Harnett County existing water distribution system shall be designed by a Professional Engineer (P.E.). The Engineer's plans and details shall be approved by HCDPU and permitted by the North Carolina Department of Environment and Natural Resources – Division of Environmental Health, Public Water Supply Section (NCDENR-DEH, PWSS) before any construction may begin on proposed water system improvements. The Professional Engineer must follow the Plan and General Requirements described in Chapters 2-4.The Contractor shall notify the Engineer if site conditions prevent the construction of the water system improvements as planned by the Engineer, approved by the HCDPU and permitted by the NCDENR-DEH, PWSS. Should site conditions warrant plan revisions then follow the procedures outlined in Chapter 4 under Section 4. 1. 11 above for plan approval of all system improvements. All materials used in the water system improvements shall meet the requirements specified in the specifications unless otherwise approved by the HCDPU Engineering Representative or the HCDPU Director in writing.

Once each project has been approved and permitted by the state, the approved plans will be returned to the HCDPU and then copies will be made for the contractor and the HCDPU Utility Construction Inspector. Copies of the state approved plans will be stamped by the HCDPU Engineering Representative as "Released For Construction," signed and dated to verify all plan changes requested by the state and the HCDPU have been addressed by the design engineer. During the pre-construction conference, the HCDPU Engineering Representative will provide a copy of the state approved plans stamped as "Released For Construction" to the contractor/developer and the HCDPU Utility Construction Inspector. Only the HCDPU approved plans as permitted by the NCDENR-DEH, PWSS stamped by the HCDPU Engineering Representative as "Released For Construction" shall be used for construction of any water system improvements to the existing Harnett County water treatment plant or the water distribution system.

Section 9.2 Materials & Design Requirements

The Professional Engineer (P.E.) shall design the water system improvements using only materials approved under Rules Governing Public Water Systems NCAC Title 15A DENR Subchapter 18C Sections .0100 through .2200 or latest edition, Harnett County Public Utilities Standards and Specifications latest edition, and included herein. Unless otherwise noted, the materials listed below are acceptable to the HCDPU for use in the design of any line extension or system improvement of the County's water distribution system. Should the P.E. desire to use materials not listed in these specifications, written permission must be obtained from both the HCDPU Director and the HCDPU Engineering Representative or designated personnel as approved by the HCDPU Director.

All material shall be free from defects impairing strength and durability and be of the best commercial quality for the purposes specified. It shall have structural properties sufficient to safely sustain or withstand strains and stresses to which it is normally subjected and be true to detail. Connection to existing water mains as indicated under the direct supervision of the HCDPU Utility Construction Inspector or equivalent engineering representative of HCDPU. Provide water main pipe, fittings, accessories, resilient seat or resilient wedge type gate valves, rubber seated butterfly valves, fire hydrants, combination air valves, air/vacuum valves, altitude control valves, check valves, cast iron valve boxes, tapping saddles, service saddles, corporation stops, polyethylene (CTS) plastic tubing, soft „K‟ copper tubing, meter setters, meter boxes, concrete valve box protective rings (donuts) and concrete valve markers as specified and where indicated per project utility plans approved by the HCDPU and permitted by the

North Carolina Department of Environment and Natural Resources – Division of Environmental Health , Public Water Supply Section.

Any engineer designing project(s) to improve the Harnett County water distribution system or to extend new water mains, water service lines or repair of the existing water distribution system shall abide the specifications herein and shall have a copy of these specifications. The specifications shall govern the design of any such system improvements and be submitted to the North Carolina Department of Environment and Natural Resources – Division of Environmental Health, Public Water Supply Section (NCDENR-DEH, PWSS) along with the utility plans and an engineer's report to obtain the appropriate "Authorization to Construct" (water) DEH permit issued by the NCDENR-DEH, PWSS for the proposed project. In addition, the P.E. shall obtain an Erosion and Sedimentation Control permit issued by the North Carolina Department of Environment and Natural Resources – Division of Land Quality (NCDENR-DLQ) for any land disturbing activity that disturbs more than one (1) acre of soil. In addition, the P.E. shall obtain Wetland permit issued by the state of North Carolina and/or United States Army Corps of Engineers (USACE) for any wetland disturbance that may be caused by the project construction. The P.E. shall complete the North Carolina Department of Transportation (NCDOT) encroachment agreement to cover all work proposed within the right-of-way of any state maintained street or road. All of these permits and agreements shall be obtained by the P.E. for the Contractor to post on the project job site for any authority having jurisdiction over the project to see the appropriate permits and agreements have been issued to the county or the developer as required by state law.

Section 9.3 Water Main Design

9.3.1 Pressure

All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on the flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow including domestic fire flow of 500 gpm in residential communities and 500 gpm in commercial areas. The normal working pressure in the distribution system should be approximately 60 psi and not less than 35 psi. All pipe to be selected for water system improvements shall be able to withstand system pressures up to 200 psi.

9.3.2 Diameter

Pipe sizes acceptable to the HCDPU are based upon nominal diameters of 2 inch, 4 inch, 6 inch, 8 inch, 12 inch, 16 inch, 20 inch, 24 inch, 30 inch and 36 inch. Larger pipe diameters shall be designed by the Professional Engineer (P.E.). Pipe diameters less than 2 inches are not acceptable for water mains. The minimum size of water main for providing fire protection and serving fire hydrants shall be 6 inches diameter. Larger size mains shall be required if necessary to allow for the withdrawal of the required fire flow while maintaining the minimum residual pressure specified herein.

9.3.3 Fire Protection

When fire protection is provided, system design shall be such that fire flows and facilities are in accordance with the requirements of the UDO (Chapter 7 Section 6.4.4) or latest revision, or a minimum of 500 gpm delivery in residential areas 500 gpm in commercial areas with 20 psi residual pressure. The local Fire Marshal having jurisdictional authority over the project may require greater flow than the minimum flows listed above.

9.3.4 Small Water Mains

Any departure from minimum requirements shall be justified by hydraulic analysis and future water use, and may be considered only in special circumstances. Generally, pipe diameters of less than 4 inches are not acceptable. However, a pipe 2 inches in diameter may be acceptable by the HCDPU on a case by case basis (short extensions, dead ends, cul-de-sacs). All pipe under 4inches in diameter shall bear the NSF # 61 certification label.

9.3.5 Hydrants

Water mains less than six (6") inches diameter or water mains not designed to carry fire flows shall not have fire hydrants connected to them. Fire hydrants shall satisfy the requirements set forth in Section 7.4.5 below and shall be installed on water mains six (6") inches in diameter or greater. The Harnett County Fire Marshal requires that fire hydrants shall be placed at each intersection including the entrance to each new development. The fire hydrants shall be located on the right side of the street as firefighting apparatus would travel into the development. Fire hydrants should be spaced out evenly along each new street with the spacing in between each fire hydrant not to exceed 1,000 feet.

9.3.6 Dead Ends and Reductions in Size of Water Line Pipe

Dead ends shall be minimized by looping of all mains whenever practical. The construction drawings shall include a two (2") inch blow off assembly at the end of each dead end water line in accordance with Detail W-2 to allow the HCDPU staff to flush the dead-end water line on a regular basis. Since the Harnett County Fire Marshal requires that each and every residential lot be within 500 feet of the nearest fire hydrant, the HCDPU requires the design engineer to measure the 500 feet along the centerline of the street from the rear property line of the last lot on any cul-de-sac or dead-end street to determine the point where the last fire hydrant should be placed on the dead-end street. Then the water line should be reduced down to a smaller water line of at least two (2") inches in diameter to serve the lots at the end of the street not to exceed 12 lots. The water line design shall include an in-line gate valve at each location where the water line diameter is reduced and the gate valve shall be located on the smaller side of the reducer fitting. This will enable the HCDPU staff to determine where the water line has been reduced in diameter.

9.3.7 Flushing

Where dead end streets will be served by water mains, there shall be provided a fire hydrant if flow and pressure are sufficient or with an approved flushing hydrant. No flushing device shall be directly connected to any sewer. Post hydrants or flushing hydrants shall be Mueller 24058 or approved equal. If the water line cannot support a flushing hydrant then the engineer shall design a two (2") inch blow off assembly to be installed at the end of the water main. The blow off assembly shall be located on the opposite corner from the last meter setter on the end of the water main. The blow off assembly shall be located at least one (1 ft.) foot within the NCDOT right-of-way at the property corner. A temporary two (2") inch blow off assembly shall be required at the end of all temporary water line terminations and the design of the blow off assembly shall include a gate valve sized equal to the main water line.

9.3.8 Size of Mains

All water mains designed to be installed within public streets and NCDOT state maintained rights-of-ways shall be sized in accordance with the HCDPU Water Distribution System Master Plan. Generally, all water mains installed within public streets and NCDOT state maintained rights-of-ways shall be at least eight (8") inches in diameter unless otherwise approved by the HCDPU Engineer. The Professional Engineer (P.E.) designing any project to extend water mains from Harnett County's existing water distribution system shall consult with the HCDPU Engineering Representative to assure the requirements of the HCDPU Water Distribution System Master Plan will be satisfied by the design of the new project. The HCDPU Water Distribution System Master Plan is subject to change at any time to meet the needs of the growing population of Harnett County and the surrounding areas.

9.3.9 Materials and Locations

The Professional Engineer must design the proposed water main extensions with the materials specified herein.

Section 9.4 Materials

9.4.1 Standards

All materials used in the construction of water line extensions to be added to the Harnett County's water distribution system shall comply with the requirements of the Safe Drinking Water Act and meet the requirements established by the American Society for Testing Materials (ASTM), the American Water Works Association (AWWA), the Ductile Iron Pipe Research Association (DIPRA), the American Association of State Highway and Transportation Officials (AASHTO) and the American National Standards Institute (ANSI), American Society of Sanitary Engineering (ASSE) and all other federal, state, county and local requirements. See Section 9.15.3 for Material Submittals and Shop Drawings.

9.4.2 Water Main Materials

A. PVC PIPE – THINWALL POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

As a minimum, PVC 2 inch through 12 inch shall conform to pressure rated Class 200 PSI standard dimension ratio SDR 21 as required by AWWA Standard C-905 unless otherwise specified. All pipe less than four (4") inches in diameter shall bear the NSF # 61 certification label indicating approval for use in public water systems. All PVC pipe shall meet the requirements of ASTM Standard D-2241. Pipe supplied with gasketed joint shall meet the requirements of ASTM Standard D-3139 and the joint gasket shall conform to the requirements of ASTM Standard F-477. All PVC pipe shall meet the requirements of NSF Standard # 14, "Plastic Piping Components and Related Materials," and Standard # 61, "Drinking Water System Components-Health Effects." The PVC pipe shall display the "NSF-PW" listing mark signifying use in potable water applications. Pipe shall be installed and tested in accordance with theses specifications and the manufacturers" suggested procedures. The PVC compound material for extruding shall meet ASTM Standard D1784. The rubber coupling rings shall meet ASTM standard D2672 or ASTM D3139.

Pipe shall be furnished in factory packaged units and each pipe shall be plainly marked with the manufacturer's name, size, material (PVC), type, grade or compound pressure rating and reference to appropriate product standards each pipe length shall bear the stamped seals of approval from Underwriters Laboratory (UL) and National Sanitation Foundation (NSF).

Harnett County Department of Public Utilities does not allow the use of glued pipe, joints or fittings to be installed in the Harnett County water distribution system. Pipe specimens shall be subjected to tests by an independent testing laboratory at such time as the HCDPU staff may direct or as specified herein. Pipe not meeting these specifications will be ordered remove from the project site by the HCDPU Utility Construction Inspector and such pipe shall be immediately removed from the job site and not transported to any portion of the project being constructed or any other project to be extended from or integrally connected to the Harnett County water distribution system.

B. DUCTILE IRON PIPE

Ductile Iron Pipe, except flange pipe, shall conform to the ANSI/AWWA C151/A21.51-02. All Ductile Iron Pipe shall be NSF # 61 certified, Pressure Class 350 for pipe 12” diameter and smaller. All larger pipes shall be Pressure Class 250. Flanged pipe shall conform to ANSI/AWWA C115/A21.15-05. The ends of pipe and fittings shall be suitable for the specified joints. Pipe and fittings shall have cement-mortar lining per ANSI/AWWA C104/A21.4-03 standard thickness and all ductile iron shall conform to the requirements of ASTM A-536, latest revision, Grade 70-50-05.

9.4.3 Joints

A. Mechanical Joints

Packing and jointing materials used in the joints of all pressure pipe shall meet the current standards of the AWWA and the HCDPU. All joints on pressure pipe installed underground shall be mechanical joint ductile iron fittings with grip rings for reinforcement.

B. Slip-On or Push-On Joints

PVC pipe shall require slip on joints with rubber gaskets. Fittings for pipe 4” up to 12” shall be DI Push Joint IPS/PVC, Class 250, ASTM A-536 and F-477 or DI Mechanical Joint with Grip Rings, Class 350, AWWA C110. For pipe smaller than 4”, fittings shall be PVC Push Joint 200 psi PR with elastomeric gaskets (synthetic type) must meet ASTM Standard D-1784, D-3139, and F-477.

C. Flanged Joints

The flanged joints shall be used in above ground connections or connection installed inside concrete vaults. Flanged joints cannot be approved for use in direct burial pipe. Flanged joints shall be manufactured by a domestic foundry in accordance with applicable ASME Code Section IX and ASNI B31.1 for pressure piping. The flanged fittings shall meet o9r exceed the requirements of AWWA C115/ANSI 21.15-05 for Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges and AWWA C207-01 for Steel Pipe Flanges for waterworks Service – Size 4 Inches through 144 inches.

D. Locking Joints

The locking joints shall be used in instances where the Engineer deems appropriate for the reinforcement of the joint. The locking joints shall be Griffin Field-Lok or approved equal for use with direct burial pipe. Locking joints must be assembled in compliance with the manufacturer’s standards and recommended guidelines.

9.4.4 Tapping Sleeves
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All tapping sleeves installed in the Harnett County water distribution system shall be constructed with stainless steel material and meet the requirements established in AWWA Standard C223-02. Stainless steel fabricated tapping sleeves shall be Romac model SST or approved equal made from stainless steel material that meets or exceeds the requirements of ANSI/AWWA C220. Cast Iron tapping sleeves are not permitted to be used in the Harnett County water distribution system. Tapping flanges for stainless steel fabricated tapping sleeves shall meet or exceed the requirements of ASTM A240, ASTM A743/A743M, or ASTM A744/A744M.

The tapping sleeve shall be installed per the manufacturer's installation instructions provided with the fabricated tapping sleeve. The manufacturer's instructions must be followed regarding support of the valve and the tapping machine during the tapping procedure. The contractor shall hydrostatically test the seal between the gasket of the tapping sleeve on the pipe of the existing water main and the gate valve before the tapping machine may be set up to perform the tap. The contractor may tap into the existing water main only after the hydrostatic pressure test has been completed with satisfactory results. For personal safety reasons, do not use a compressible fluid medium (such as air) to check for water tightness.

The HCDPU Utility Construction Inspector must witness the hydrostatic testing on the tapping sleeve and valve assembly as well as the tapping procedure on the existing water main. The coupon removed from the existing water main when the water line is tapped shall be given to the HCDPU Utility Construction Inspector. The HCDPU Utility Construction Inspector shall return the coupon to the HCDPU Engineering Representative for a visual analysis. Additional non-destructive analysis may be performed by the HCDPU Engineering Representative on the coupon to determine the condition of the existing water main. Coupons removed from AC pipe shall be sealed in a plastic bag to reduce the potential for fraying or dispersal of asbestos material. 135

9.4.5 Gaskets

Gaskets shall be molded or extruded natural or synthetic rubber free of porous areas and visible defects. Reclaimed rubber shall not be used. Unless otherwise specified, gaskets shall be suitable for water service to 150°F (65°C). Gaskets for the body of the tapping sleeve shall meet the requirements of ASTM D2000. Gaskets needed for the body of the tapping sleeve shall have a minimum diameter of 50 and minimum tensile strength of 800 psi. Gaskets for flanges shall conform to ANSI/AWWA C207.

9.4.6 Valves

A. Gate Valves (12 inches and smaller)

Gate valves installed in the Harnett County water distribution system shall be manufactured by Mueller, American Flow Control, M&H, Kennedy, Waterous or approved equal. Gate valves shall be cast iron conforming to AWWA standard C500 and rated for a working pressure of 200 psi for valves up to 12 inches in diameter and 150 psi for valves larger than 12 inches in diameter. Gate valves shall be mechanical joint, resilient seat type valves with non-rising stem, "0" ring seal, open left with 2-inch square operating nut. Gate valves shall be of one manufacturer. It is strongly recommended that instruction manuals supplied by the valve manufacturer be reviewed in detail before installing gate valves. The contractor should inspect the valve and accessories on the jobsite prior to installation.

Gate valves shall be resilient seated or resilient wedge type gate valves suitable for use with buried piping. All gate valves shall conform to AWWA standard C509-01 or latest version and/or AWWA standard C515-01 or latest version and they shall be NSF 61 certified. All valves smaller than 24 inches in diameter shall be configured and installed in a vertical position. Gate valve end connections shall be mechanical joint with grip rings for buried pipe or flanged joint for pipe installed above ground and for pipe installed inside an underground vault or enclosed structure as indicated by the project drawings. Gate valves with flanged joints shall only specified for installation within an underground vault permitting personnel access and they must be equipped with hand wheels for operation. Gate valves shall have a non-rising valve stem with a 2-inch square operating nut. Gate valves shall open by counter-clockwise rotation of the operating nut. Stuffing boxes shall have "0" ring stem seals, except for those valves for which gearing is specified, in which case use conventional packing in place of the "0" ring stem seal. Stuffing boxes shall be bolted and constructed so as to permit easy removal of the parts for repair. The wedge shall be cast iron, completely encapsulated with resilient material. The resilient sealing material shall be permanently bonded to the cast iron wedge with rubber-tearing bond to meet ASTM standard D-429. The gate valve stem and stem nut shall be copper alloy. The body and bonnet shall be coated both interior and exterior with a fusion bonded heat cured thermo setting material meeting all application and performance requirements of the AWWA standard C550-05.

B. Check Valves

Check valves shall be manufactured by Mueller, American Flow Control, M&H, Kennedy or approved equal in accordance with AWWA standard C508-01 or latest version. Check valves shall be swing type check valves with iron or steel body and cover and flanged ends. Check valves shall have iron disc with bronze disc ring and seat ring. Valve to be lever and weight controlled with lever and weight on left side of valve when viewing valve in the direction of flow. All internal iron surfaces of the valve shall be coated with a minimum of 10 mils of fusion bonded or liquid epoxy, approved for potable water.

C. Butterfly Valves

Butterfly valves installed in the Harnett County water distribution system shall be manufactured by Mueller, Kennedy, Pratt, American Flow Control, Dezurik Water Controls, Keystone or approved equal. Butterfly valves shall conform to AWWA standard C504-06 or latest version for Class 150B service and shall be NSF 61 certified. Valve bodies shall be constructed of cast iron meeting the ASTM standard A-126 Class B and conform to AWWA standard C504-06 for laying lengths and minimum body shell thickness. Butterfly valves end connections shall be mechanical joint or flanged joint as indicated by the project drawings. Butterfly valves with flanged joints shall only specified for installation within an underground vault permitting personnel access and they must be equipped with hand wheels. 136

Valve discs shall also be made of cast iron meeting the ASTM standard A-126 Class B or ASTM standard A-48 Class 40 in sizes 24" and smaller. Disc shall be furnished with 316 stainless steel seating edge to mate with rubber seat on the body. Valve seat shall be Buna-N rubber located on the valve body. Valves 20 inches in diameter and smaller shall have bonded seats that meet test pressures outlined in the ASTM standard D-429 Method B. For valve sizes 24 inches in diameter and larger, the valve seats shall be retained in the valve body by mechanical means without the use of metal retainers or other devices located in the flow stream.

Butterfly valve shafts shall be manufactured of 18-8 type 304 stainless steel conforming to ASTM standard A-276. Shaft seals shall be standard self-adjusting split V packing and shaft seals shall be of a design allowing replacement without removing the shaft. Valve bearings shall be sleeve-type, corrosion resistant and self-lubricating. The valve shaft bearings shall be heavy duty bronze, properly fitted into thee hubs which are integrally cast into the valve body.

Valve actuators shall be fully grease packed and have stops in the open position. The actuator shall have a mechanical stop which will withstand an input torque of 450 ft.-lbs against the stop. The traveling nut shall engage alignment groves in the housing. The actuator shall have a built in packing leak bypass to eliminate possible packing leakage into the actuator housing. All internal and external surfaces shall be covered with a polyamide cured epoxy coating applied over a sand blasted “new white metal surface” per SSPC-SP10 to a minimum of 6 mils in compliance with AWWA standard C-550-05 or latest version. External painting, hydrostatic testing, travel stop adjustments and crating for shipment shall be completed by the manufacturer in accordance with the AWWA standard C504-06 or latest version. It is strongly recommended that instruction manuals supplied by the valve manufacturer be reviewed in detail before installing butterfly valves. The contractor should inspect the valve and accessories on the jobsite prior to installation.

Valve actuators shall be fully grease packed and have stops in the open position. The actuator shall have a mechanical stop which will withstand an input torque of 450 ft.-lbs against the stop. The traveling nut shall engage alignment groves in the housing. The actuator shall have a built in packing leak bypass to eliminate possible packing leakage into the actuator housing. All internal and external surfaces shall be covered with a polyamide cured epoxy coating applied over a sand blasted “new white metal surface” per SSPC-SP10 to a minimum of 6 mils in compliance with AWWA standard C-550-05 or latest version. External painting, hydrostatic testing, travel stop adjustments and crating for shipment shall be completed by the manufacturer in accordance with the AWWA standard C504-06 or latest version. It is strongly recommended that instruction manuals supplied by the valve manufacturer be reviewed in detail before installing butterfly valves. The contractor should inspect the valve and accessories on the jobsite prior to installation.

D. Surge Relief and Backpressure Valves

Surge relief and backpressure valves shall be flanged iron globe body; fully bronze mounted; external pilot operated with free floating piston; operated without springs, diaphragm, or levers; single seat with seat bore equal to size of valve. Valves shall be manufactured in accordance with AWWA standard C506. All surfaces of iron castings shall be coated with a minimum of two coats of a serviceable grade of asphaltic base metal paint. The valve design shall be such that repairs and internal dismantling of the main valve may be done without removing the valve from the water main. Valve working and surge pressures will be shown on the drawings or designated in the "Special Conditions." . It is strongly recommended that instruction manuals supplied by the valve manufacturer be reviewed in detail before installing surge relief and backpressure valves. The contractor should inspect the valve and accessories on the jobsite prior to installation.

E. Air Release/Air Relief Combination Valves for Water Lines

The air release/air relief valve shall include a vacuum check unit. The air release valve shall be installed at the highest point(s) on the water main as indicated by the project plans in order to release air in the main as the water main is filling and allow air to enter when the water main is being emptied to prevent pipe collapse when subject to negative pressure or vacuum. The air release valve shall be manufactured to meet or exceed the requirements of ANSI/AWWA C512-04 or latest edition and shall be NSF 61 certified. Valves shall be iron manufactured with screwed inlet connections and rated for a working pressure of 150 psi. The air release valves shall be Crispin Universal Air Valve model U20 with 1/4" orifice, Val-Matic, A.R.I. or approved equal. The valve shall be operated through a compound level system that will seal both the pressure orifice and the air vacuum orifice simultaneously. This lever system shall permit a ¼” orifice to release an accumulation of air from the valve body at a capacity of 98 cfm of air at 150 psig. The function lever of the valve shall permit a positive disengagement of the main valve from the large orifice. As the float drops the pressure decreases, the disengagement of the main valve from the large orifice shall be immediate and not limited to an initial draw of vacuum. The air release valve(s) shall be two (2”) inches in diameter with national pipe threads (NPT) or ANSI Class 125 flanged inlet connection and shall be a cast iron body, top and inlet flange (where required), stainless steel float and trim with a BUNA-N rubber seat. Valves, which operate the pressure plunger via a single lever and fulcrum, will not be acceptable. A protect top shall be supplied to keep debris from entering the outlet of the valve. Air release valve(s) shall be two (2") inches in diameter include a two (2") inches in diameter, non-rising stem (NRS) solid disc, inside screw bonnet gate valve with a 200 WOG pressure rating and conforming to Federal Specifications MSS SP-80. Each air release valve shall be installed inside a manhole as shown in detail sheet of the project plans if included with the project. Air release valves are not required for most water line extensions.

F. Indicator Posts

Indicator Posts shall be supplied for gate valves and butterfly valves as specified in the project plans. Indicator Posts shall be FM approved and installed to meet the established requirements of the Harnett County Fire Marshal having jurisdiction over the project. Indicator posts shall have a means to lock the valve open or closed.

9.4.7 Fittings and Bends

Pipe manufacturers have a specified amount of deflection that the pipe can bend. If the design of any water line will exceed the manufacturer's tolerance for deflection then the design shall incorporate the use of bends and fittings to accomplish turns, offsets and other adjustments for water line alignment. All fittings and bends shall be installed with mechanical joints and grip rings for pipe sizes up to 12" diameter and be installed with appropriate concrete reaction blocking. All fittings and bends shall be installed with mechanical joints and Megalugs for pipe sizes over 12" diameter and be installed with appropriate concrete reaction blocking. The fittings shall conform to the following applicable AWWA standards:

C104/A21.4-03	Cement- Mortar Lining for Ductile Iron Pipe & Fittings for Water
C110/A21.10-03	Ductile Iron & Gray Iron Fittings for Water
C111/A21.11-00	Rubber Gasketed Joints for Ductile Iron Pressure Pipe &Fittings
C900-97	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4" through 12"
C901-02	Polyethylene (PE) Pressure Pipe and Tubing, ½" through 3" for Water Service
C903-05	Polyethylene-Aluminum-Polyethylene & Crossed- Linked Polyethylene-Aluminum-Cross-Linked Polyethylene Composite Pressure Pipes, ½" through 2" for Water Service
C905-97	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14" through 48", For Water Transmission and Distribution
C906-99	Polyethylene (PE) Pressure Pipe and Fittings, 4" Through 63", For Water Transmission and Distribution
C907-04	Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4" Through 12", For Water Distribution.

Section 9.5 Main Line Valves

9.5.1 Valve Location

Sufficient valves shall be provided on all new water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves shall be located at intervals not to exceed 700 feet in any commercial district and not more than 1,000 feet in residential districts. Two valves are required on each tee, one on the main line and one on the lateral line unless the water mains are looped. Three valves are required for all tees where the water mains are looped. Four valves are required for all crosses, two valves on the branches or laterals and two in-line valves. An in-line gate valve shall be included with each hydrant tee except at fire hydrants located at intersections. Each valve shall be provided with and concrete valve marker with brass insert stamped with distance and direction denoted. All valves shall require concrete valve location markers, except within interior subdivisions, where the Professional Engineer (P.E.) shall reference valves on the “As-built” Record Drawings to at least two permanent above ground structures. The concrete valve location markers should be included on the “As-built” Record Drawings.

9.5.2 Location of Bends in Water Mains

Bends and fittings shall be depicted in plans where the water mains shall turn more than the allowable deflection will be exceeded by the design. All bends greater than 22.5° degrees shall be marked in the field by setting two concrete markers at the edge of the right-of-way or easement in line with the bends. The top of the markers shall be stamped with the distance to each bend or fitting and the markers shall be turned backwards so the HCDPU staff will not confuse them for valve markers or blow off markers.

9.5.3 Valve Operation and Protection

All valves (gate valves, butterfly valves, plug valves, etc.) installed in the Harnett County Water Distribution System shall meet AWWA standards and be provided with an adjustable cast iron valve box with an 18" x 18" x 6" concrete collar in accordance with the HCDPU Standard Details. The valves that are installed more than eight (8 ft.) feet below finished grade shall be provided with extensions on the operating nuts to raise them up to be within six (6 ft.) feet of the finished grade.

Section 9.6 Fire Hydrants

9.6.1 Location and Spacing

Hydrants shall be provided at each street intersection and at intermediate points between intersections as recommended by the Harnett County Fire Marshal. Generally, hydrant spacing may range from 500 to 1,000 feet depending on the area being served. Larger spacing increments may be allowed in very rural areas upon approval of the HCDPU. The fire hydrants installed to serve new residential subdivisions shall be installed on the right side of the street in which fire and rescue vehicles travel when entering the subdivision and the water main shall be installed on the same side of the street to avoid having hydrant legs installed under the paved streets. The location of the fire hydrant shall be approved by the Fire Marshal having jurisdiction over the project site.

9.6.2 Valves and Nozzles

Fire hydrants shall have a bottom valve size of at least 5-1/4 inches, one 4 1/2 inch pumper nozzle and two 2 1/2 inch hose nozzles.

9.6.3 Hydrant Leads

The hydrant lead shall be a minimum of six inches in diameter. Auxiliary valves shall be installed in all hydrant leads and bolted firmly to the hydrant tee with threaded rod. The threaded rod shall be coated to prevent corrosion.

9.6.4 Drainage

Hydrant drains shall have a gravel pocket or dry well provided unless the natural soil will provide adequate drainage. Hydrant drains shall not be connected to or located within 10 feet of sanitary sewers or storm drains.

9.6.5 Type

Fire hydrants shall conform to the latest edition of AWWA C502-05 for Dry Barrel Fire Hydrants. Fire hydrants must have main opening valves of 5¼"diameter. All fire hydrants must be installed in accordance with the requirements established by the HCDPU standard details and the Harnett County Fire Marshal. In order to reduce the number of different brands and models that HCDPU must stock parts and repair kits for and for standardization and maintenance reasons, HCDPU only the following fire hydrants are permitted to be installed in Harnett County:

A. Mueller - Super Centurion 250 A-423 model with a 5¼" main valve opening three way (two hose nozzles and one pumper nozzle);

B. American Darling - Mark B-84-B model with a 5¼" main valve opening three way (two hose nozzles and one pumper nozzle);

C. Waterous - Pacer B-67-250 model with a 5¼" main valve opening three way (two hose nozzles and one pumper nozzle).

Fire hydrants shall meet or exceed the AWWA C502, latest edition and have a rated working pressure of at least 250 psig. All fire hydrants shall be dry-barrel type with two – 2 ½" hose nozzles and one – 4 ½" pumper nozzle all having standard NPT threads. All fire hydrants shall carry a 10 year warranty from the date stamped on the fire hydrant. Fire hydrant(s) shall be listed by Underwriters Laboratories, Inc., as meeting their standard UL 246, latest edition and approved by the Factory Mutual Research Corporation (FMRC) and installed to meet the established requirements of the Fire Marshal having jurisdiction over the project.

9.6.6 Fire Hydrant Testing, Painting and Color Coding

Fire hydrants shall be painted solid red before installation by the manufacturer. Once the fire hydrant has been inspected, pressure tested and accepted for service by HCDPU, and then the utility contractor shall paint another coat of red paint on all fire hydrants and then notify the Harnett County Fire Marshal or the Fire Marshal having jurisdiction over the project to request an inspection of each fire hydrant installation. Any deficiencies noted by the Fire Marshal shall be corrected before the fire hydrant will be accepted by the HCDPU and allowed to be placed into operation.

The contractor shall provide the HCDPU with one fire hydrant wrench for each fire hydrant installed in the Harnett County water distribution system up to a maximum of two wrenches per project. The local fire department shall be responsible to conduct any additional pressure testing and/or fire flow testing annually on the fire hydrants following acceptance by the HCDPU. Each fire hydrant shall be provided with chains for each nozzle cap. The fire hydrants shall be installed with a four (4 ft.) feet bury depth with three feet of cover to allow the base of the hydrant to be slightly above finished grade. Should the hydrant tee be installed at depths greater than four (4 ft.) feet then the contractor shall provide all bends, fittings, pipe and joints to raise the fire hydrant to the proper elevation so the base of the fire hydrant shall be no more than twelve (12") inches above the finished grade.

Each fire hydrant may be Color Coded as necessary by the local fire department. The top cap may be repainted by the local fire department which will designate the specific pressure and flow characteristics of each fire hydrant. The National Fire Protection Association (NFPA) standard calls for bonnets and caps to be color-coded to indicate the hydrant's available flow at 20 psi. Standard color codes stipulated by the National Fire Protection Association (NFPA) are as follows:

NFPA 291, Chap. 3

Class C	Less than 500 GPM	**Red**
Class B	500-999 GPM	**Orange**
Class A	1000-1499 GPM	**Green**
Class AA	1500 GPM & above	**Light Blue**

Section 9.7 Air Relief Valves

9.7.1 Air Relief Valves

At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

9.7.2 Air Relief Valve Piping

The open end of an air relief pipe from automatic valves shall be extended to at least one foot above finished grade and provided with a stainless steel screened, downward facing elbow. The pipe from a manually operated valve shall be extended to the top of the pit.

9.7.3 Chamber Drainage

Chambers, pits or manholes containing valves, blow offs, meters, or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer, nor shall blow offs or air relief valves be connected directly to any sewer. Such chambers or pits shall be drained to the surface or the ground where they are not subject to flooding by surface water or to absorption pits underground. If gravity drainage is impractical, a small sump pump with float control shall be included in the design along with the electrical service connection to provide power for the sump pump. Generally, the HCDPU prefers to avoid the use of sump pumps unless absolutely necessary for the proper operation of the system.

Section 9.8 Bore and Jack Method for Water Lines to Cross NCDOT Right-of-Ways

9.8.1 Bore and Jack Method

All water lines that will cross an established NCDOT maintained street shall be permitted by the North Carolina Department of Transportation (NCDOT) District Engineer in a three party NCDOT Encroachment Agreement. Any bore and jack work shall be accurately described in the three party NCDOT Encroachment Agreement between the developer, the HCDPU and the NCDOT. All water lines that will cross an established NCDOT maintained street shall be designed to be installed by the bore and jack method to avoid open cuts in the existing pavement. Open cuts on established streets and roads are not allowed by the HCDPU unless approved by NCDOT in writing in the three-party NCDOT Encroachment Agreement.

9.8.2 Carrier Pipe

The carrier pipe for any road crossing should be sized equal to or larger than the water line being extended to accommodate future development when practical. The carrier pipe shall be the same material as the water line unless conditions will prevent the installation of the water line using the same material. Generally, the HCDPU prefers that all carrier pipe shall be ductile iron pipe installed inside a steel casing pipe. The use of PVC pipe material should be avoided under the paved street inside the NCDOT right-of-ways. The carrier pipe shall include a valve on each side of the street to afford the HCDPU staff a means to isolate the water line on both sides of the street. The valves may not be required if the water line is greater than 20 inches in diameter.

9.8.3 Casing Pipe

Where indicated on the plans and/or as required by the NCDOT, water lines shall be installed under highways by bore and jack method with the carrier pipe (water line) installed inside a spiral wound steel casing. The contractor shall be required to notify NCDOT's District Engineer and Harnett County Department of Public Utilities at least five (5) days prior to work starting. Casing shall have a minimum cover of three (3) feet of cover and extend a minimum of two (2) feet either side of pavement but preferably from ditch line to ditch line where practical as stipulated in the approved project plans. The utility contractor must verify all grades and alignment prior to set up. Contractor shall install casing in a manner not to create drainage beneath the highway. Casing shall be welded steel to conform to ASTM A-53 Grade "B", ASTM A-139 Grade "B" or better. Although the casing is not considered a pressure vessel, the welding on the casing shall be performed by a qualified welder in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. The minimum inside diameter of the casing as compared to the largest diameter outside diameter of the carrier pipe, joints or couplings shall be as follows:

Casing Pipe Nominal Size Diameter O.D.	Casing Pipe Diameter Amount Greater than Carrier Pipe
Less than 6 inches	Not less than 4 inches
6 inches and larger	Not less than 6 inches

Casing Pipe Diameter	Minimum Wall Thickness
6”-14”	1/4"
16”-18”	5/16”
20”-22”	3/8”
24”-26”	7/16”
28”-32”	1/2"
34”-42”	9/16”

Section 9.9 Separations

9.9.1 General

The following factors shall be considered in providing adequate separation:

A. Materials and type of joints for water and other non-potable water lines,

B. Soil conditions,

C. Service and branch connections into the water main and other non-potable water lines,

D. Compensating variations in the horizontal and vertical separations,

E. Space for repair and alterations of water and sewer pipes, and

F. Offsetting of pipes around manholes.

9.9.2 Vertical Separations

The following minimum vertical separations shall be provided for any water line extension of Harnett County's existing water distribution system:

	Utilities or Structures	Vertical Separation Distance
A.	Storm sewers and other utilities not listed below;	2 feet
B.	Water mains (potable water over potable water)	2 feet
C.	Reclaimed water lines (potable water over reclaimed water);	2 feet
D.	Final earth grade (finished grade);	3 feet

Ductile iron pipe shall be used for any water line extension off of Harnett County's existing water distribution system where the above minimum vertical separations cannot be maintained. The design shall maintain vertical separations to satisfy state minimum requirements where the ductile iron pipe is used to satisfy the HCDPU requirements above.

9.9.3 Horizontal Separations

The following minimum horizontal separations shall be provided for any water line extension of Harnett County's existing water distribution system:

	Utilities or Structures	Horizontal Separation Distance
A.	Edge of Pavement (EOP);	3-5 feet
B.	Storm sewers, power poles and other utilities not listed below;	5 feet
C.	Sanitary sewers and reclaimed water mains or associated lines;	10 feet
D.	Any non-permanent structures or improvements (fencing, landscape material, etc.) ;	10 feet
E.	Any building foundation, basement or subsurface structure;	25 feet
F.	Any swimming pool	30 feet

Ductile iron pipe shall be used for any line extension of County's existing water distribution system where the above minimum horizontal separations cannot be maintained, except for the edge of pavement (EOP). The design shall maintain horizontal separations to satisfy state minimum requirements where the ductile iron pipe is used to satisfy the HCDPU requirements above.

9.9.4 Sewer Manholes/Storm Drainage

No water pipe shall pass through or come in contact with any part of a sewer manhole or storm drain.

9.9.5 Exception

The HCDPU and the North Carolina Department of Environment & Natural Resources, Division of Environmental Health – Public Water Supply Section must specifically approve any variance from the separation requirements of Sections 9.10.2, 9.10.3 and 9.10.4 when it is impossible to obtain the specified separation distances.

Section 9.10 Surface Water Crossings

Surface water crossings or under water crossings present special problems. The HCDPU shall be consulted before final plans are prepared. Generally, the HCDPU will design and build the water lines in these areas with specific approval of the Harnett County Board of Commissioners as permitted by the state, unless a developer or land owner desires to fund the project engineering and construction costs. These water crossings will be designed and constructed in accordance with all federal, state and local requirements. An Engineer working on a project design that will include the crossing of a lake, river or stream must consult with the HCDPU Engineer before submitting plans to the HCDPU for review or approval.

9.10.1 Above Water Crossing

The pipe shall be adequately supported and anchored, protected from damage and freezing and accessible for repair or replacement.

9.10.2 Under Water Crossing

A minimum cover of three (3 ft.) feet shall be provided over the pipe. When crossing water courses which are greater than 15 feet in width, the following shall be provided.

A. The pipe shall be of special construction, having flexible watertight joints;

B. Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair. The valves shall be easily accessible and not subject to flooding; and

C. A blow off shall be provided on the side opposite the supply of service.

Section 9.11 Easements

In all cases when it is necessary to construct water mains abutting private property, an easement designated specifically for construction, operation and maintenance of water/sewer improvements shall be dedicated exclusively to the Harnett County Department of Public Utilities. In no event shall the easement be allowed to be upon privately held single family lots. Dimensions of the easement shall be in keeping with the herein stated separation requirements. A minimum permanent easement width of 20' shall be provided where it is necessary to install water mains outside of public highway right-of-ways, such as planned unit developments, private road right-of-ways and commercial areas, etc. or a combination of 15' common property easement and 15'' building setback for lines installed between adjacent parcels.

Section 9.12 Cross Connections and Interconnections

9.12.1 Cross Connections

There shall be no connection between the distribution system and any pipe, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system. Connections between private individual's wells shall not be allowed. This procedure is not acceptable by the North Carolina Department of Environment & Natural Resources (NCDENR) No fire protection water line, irrigation water system, commercial or industrial water system shall be allowed to connect to the Harnett County water distribution system without the proper backflow protection. At a minimum, these connections shall have a dual check valve assembly (DCVA) or reduced pressure zone (RPZ) assembly installed between their water system and the Harnett County water distribution system to provide adequate backflow protection. Each service connection shall be evaluated by the HCDPU Backflow and Cross Connection Operator in Charge (ORC) for proper compliance to this requirement. Each business owner shall be responsible to satisfy all current and future requirements with respect to the backflow and cross connection regulations as set forth in all federal, state, county, and local regulations. All connections to the Harnett County water distribution system shall be tied into the potable water system without prior approval and in keeping with the County's Water Conservation Resolution, as amended. Whenever there is a question of cross connection the engineer shall provide reduce pressure zone backflow prevention.

9.12.2 Cooling Water

Neither steam condensation nor cooling water from engine jackets, cooling towers, heat exchangers or any other heat transfer devices shall be returned to the sanitary sewer collection system. Potable water supply shall not be connected without proper back flow prevention. 145

9.12.3 Interconnections

The approval of the HCDPU shall be obtained for interconnections between potable water supplies and non-potable water sources (i. e. irrigation systems). in the event the interconnections are allowed by the HCDPU, such connections shall be designed in keeping with the Ten States Standards, the State Primary Drinking Water Regulations and the HCDPU Water Conservation Resolution.

Section 9.13 Water Services and Plumbing

9.13.1 Water Services

The County will be responsible for the initial installation of a water service connection for all single family lots, including a main line tap, water service from the main line to the user's property line (or within the defined public or private road right-of-way), a meter box, a meter, a check valve or backflow prevention device, and a cut off valve. It shall be the property owner's responsibility to maintain and/or install all pertinent lines, connection fittings beyond the check valve/back flow prevention device and/or gate valve to the premises or building units being served.

9.13.2 Service Lines

All 3/4”, 1”and 2” water service lines shall be copper tubing size (CTS) Cross-linked PEX SDR 9 or approved equal conforming with ASTM F876 with a NSF marking and PEX1006 coding polyethylene plastic tubing.

When service mains are installed under roadways or sidewalks the must be installed inside a casing. Copper water service lines shall be at „K‟ copper. The 3/4” water service lines shall be installed inside a schedule 40 PVC or steel casing of at least two (2”) inches in diameter. The and 1” water service lines shall be installed inside a schedule 40 PVC or steel casing of at least three (3”) inches in diameter. The 2” water service lines shall be installed inside a schedule 40 PVC or steel casing of at least four (4”) inches in diameter. Each casing shall be installed by an open cut for new streets or by the bore and jack method for all existing paved streets. The casing shall be at a minimum of three (3 ft.) feet below surface of street and each ditch line on either side of the street.

9.13.3 Plumbing

Water services and plumbing shall conform to relevant local and/or state plumbing codes, or to the National Plumbing Code. All water service lines beyond the meter shall be inspected by the building code inspector having jurisdiction over the project. The HCDPU will require the plumber to install a valve (gate valve or ball valve) on the customer’s side of the meter setter within 12 to 18 inches of the meter box. The HCDPU meter readers will not release a meter to be installed in the meter setter unless the valve has been installed by the plumber.

9.13.4 Booster Pumps

Individual home booster pumps shall not be considered or required for any individual service from the public water supply mains.

9.13.5 Fire Protection

Connections to the HCDPU system for the purpose of individual sprinkler systems in commercial buildings, shall provide a remote double detector check valve (double check) assembly located outside of the structure being served that can be readily accessible by HCDPU staff at all times for inspection. Fire lines entering private property shall be the full responsibility of the owner and must be supplied with a shut-off valve at or before the property line to delineate the responsibility of the HCDPU. Sprinkler systems in commercial and industrial projects must meet all requirements established by the state and local fire codes as well as the standards established by the National Fire Protection Association (NFPA). The Harnett County Fire Marshal shall review plans for all sprinkler systems and be present for a system test before the sprinkler system can be accepted and placed into operation.

Section 9.14 Service Meters

Each service connection shall be individually metered and conform to the latest AWWA standards. All brass meters shall be required. ABB, Kent, Dewey Brothers C700 meters shall be used for service connections between three-fourths (¾”) inch and 1” shall be required. ABB, Kent, Dewey Brothers C3000 shall be used for service connections greater than or equal to two (2”) inches shall be required. Meter boxes for the services two (2”) inches or smaller shall be constructed with ABS plastic. Solid cast iron lids shall be installed for service connections of three-fourths (¾”) inch. Solid ABS plastic lids with cast iron reader windows in the center shall be installed for service connections of one (1”) inch up to two (2”) inches. 146

All metered services greater than two (2”) inches shall be installed inside a prefabricated, pre-stressed concrete vault in accordance with Harnett County’s standard details. Meters two (2”) inches and under shall be installed by the HCDPU. Metered services over two (2”) inches shall be installed by the contractor and the contractor shall provide the meter for the project; however, the meter should be purchased through the HCDPU supplier and only released once the project has been approved by the NCDENR – DEH, PWSS and the HCDPU. Concrete meter vaults shall house the bypass line, the gate valves, the meter, the strainer, flanges, couplings and have positive head for drainage or be equipped with a sump pump and a 120 volt GFCI receptacle for a light and a sump pump. The GFCI receptacle shall be installed in accordance with the NEC requirements. If the power is supplied for the sump pump then the vault shall be equipped with a fluorescent light having a zero (0°) degree ballast. 147

Please see Chapter 12, General and Special Conditions, Special Construction Technical Specifications for additional information and requirements for construction.

Section 9.15 Construction of Approved Final Drawings and Plans

9.15.1 Design Plans and Construction of Water System Improvements

Contractors shall install all water system improvements per the Professional Engineer's design as approved by HCDPU and permitted by the North Carolina Department of Environment and Natural Resources – Division of Environmental Health, Public Water Supply Section (NCDENR-DEH, PWSS) unless the existing site conditions preclude such installation or site conditions significantly impact the project construction. Should site conditions warrant plan revisions then the contractor shall follow the procedures outlined in Section 4. 1. 11 above. All materials used in the construction of any water system improvements to the existing Harnett County water distribution system shall meet the requirements specified in the sections below unless otherwise approved by the HCDPU Engineering staff.

Once each project has been approved and permitted by the state, the approved plans will be returned to the HCDPU and then copies will be made for the contractor and the HCDPU Utility Construction Inspector. Copies of the state approved plans will be stamped by the HCDPU Engineering Representative as "Released For Construction," signed and dated to verify all plan changes requested by the state and the HCDPU have been addressed by the design engineer of record. During the pre-construction conference, the HCDPU Engineer or designated staff shall provide a copy of the NCDENR-DEH, PWSS (state) approved plans, marked as Final drawings by the Professional Engineer (P.E.) and stamped by the HCDPU as "Released For Construction" to the contractor/developer and the HCDPU Utility Construction Inspector. Only the state approved plans stamped by the HCDPU Engineer as "Released For Construction" shall be used for construction of any water system improvements to Harnett County's existing water distribution system.

9.15.2 Materials & Design Requirements

The utility contractor shall furnish all types of pipe and other incidentals required for the construction of a complete water system as shown on the plan drawings and as specified herein. Unless otherwise noted, the materials listed below are acceptable to the HCDPU for use in the construction of any extension of Harnett County's water distribution system. Should the contractor desire to use materials not listed in these specifications, written permission must be obtained from both the Professional Engineer (P.E.) of record and the HCDPU Engineering Representative or designated personnel as approved by the HCDPU Director. The developer's Engineer of Record will review all shop drawings for conformance with HCDPU specifications prior to submittal to HCDPU. The shop drawing submittal to HCDPU shall include a cover letter by the developer's Engineer of Record certifying conformance with HCDPU specifications and summarizing any exceptions or concerns relative to approved drawings and/or HCDPU standards.

9.15.3 Material Submittals and Shop Drawings

All materials to be used in the extension of or connection to the existing Harnett County water distribution system must be approved by the Developers Engineer and HCDPU Engineering Representative prior to purchase and delivery to any project site. Submit three (3) copies of the material specification sheets and all associated shop drawings including a cover letter summarizing all material to be used in the in the proposed project to the Developers Engineer and HCDPU Engineering Representative prior to the Pre-Construction conference to demonstrate compliance with the stipulated requirements as set forth herein these specifications under the "General

Conditions." The developer's Engineer of Record will review all shop drawings for conformance with HCDPU specifications prior to submittal to HCDPU. The shop drawing submittal to HCDPU shall include a cover letter by the developer's Engineer of Record certifying conformance with HCDPU specifications and summarizing any exceptions or concerns relative to approved drawings and/or HCDPU standards.

9.15.4 Project Specifications, Encroachments and Permits

Any utility contractor performing work to the Harnett County water distribution system to extend new water mains, water service lines or repair of the existing water distribution system shall abide the specifications herein and shall have a copy of these specifications on the job site along with the appropriate "Authorization to Construct" (water) permit issued by the North Carolina Department of Environment and Natural Resources – Division of Environmental Health, Public Water Supply Section (NCDENR-DEH, PWSS) for the proposed project. The contractor shall have a copy of the Erosion and Sedimentation Control permit issued by the North Carolina Department of Environment and Natural Resources – Division of Land Quality (NCDENR-DLQ) for any land disturbing activity that disturbs more than one (1) acre of soil. The contractor shall have a copy of any Wetland permit issued by the state of North Carolina and/or United States Army Corps of Engineers (USACE) for any wetland disturbance that may be caused by the project construction. The contractor shall have a valid copy of the North Carolina Department of Transportation (NCDOT) encroachment agreement to cover all work proposed within the right-of-way of any state maintained street or road. Connection of new streets or driveways to the existing streets and roads shall be made by only with the approved Driveway Permits issued by the NCDOT. All of these permits, agreements, etc. shall be posted on the project site during the construction for any authority having jurisdiction over the project to see the appropriate permits and agreements have been issued to the county and/or the developer as required by state law.
Contractors shall provide the HCDPU Engineer with copies of any permits, encroachment agreements or other documents obtained by the Professional Engineer during the Pre-Construction Conference. 149

9.15.5 Material Transportation, Storage and Protection

The Contractor shall receive at least one (1) of the three (3) copies stamped as reviewed by the Engineer and HCDPU Utility Construction Inspector prior to ordering any material. All materials shall be transported by the supplier to the contractor at the project site and handled by both parties in a manner to avoid damage. All items damaged in transit shall be returned to the supplied for full credit and similar materials in new condition shall be provided to replace any damaged materials. The contractor shall store and protect all materials that will not be installed immediately. PVC pipe shall be provided protection against sunlight exposure. All materials shall be kept clean and free of contamination. Contaminated materials shall be removed from the project site and replaced with similar material in new condition.

Section 9.16 Site Work

9.16.1 Site Clearing

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the performance and completion of all site clearing, tree protection, and demolition as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades.

Work included within the project consists of but is not limited to the following:

- Clearing for Booster Pump Stations as needed.

- Clearing for Elevated Tank as needed.
- Clearing for all water line installation as needed.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

B. Quality Standards: Perform all work in accordance with OSHA requirements and requirements of Environmental Protection Agency in addition to State and Local requirements.

C. Protection of Work Area: Provide barricades, coverings, or other types of protection necessary to prevent damage to existing improvements indicated to remain in place. Protect improvements on adjoining properties as well as those on Owner's property. Restore any improvements damaged by this work to their original condition, as acceptable to Owner or other parties or authorities having jurisdiction. Protect existing trees and other vegetation indicated to remain against unnecessary cutting, breaking or skinning of roots, skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary fences, barricades or guards as required to protect trees and vegetation to be left standing.

D. Improvements on Adjoining Property: Authority for performing removal and alteration work on property adjoining owner's property will be obtained by Owner prior to award of contract.

E. Site Clearing: Remove trees, shrubs, grass, weeds, and other vegetation, improvements, or obstructions that interfere with new construction. Also remove such items elsewhere on site or premises as specifically indicated. Removal includes new and old stumps of trees and their roots. Carefully and cleanly cut roots and branches of trees indicated to be left standing where such roots and branches obstruct new construction.

F. Clearing and Grubbing: Clear project site of trees, shrubs, and other vegetation, except for those indicated to be left standing. Completely remove stumps, roots, and other debris protruding through ground surface. Use only hand methods for grubbing inside drip line of trees indicated to be left standing. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated. Place fill material in horizontal layers not exceeding 6 inches loose depth and thoroughly compact to a density equal to adjacent original ground.

G. Removal of Improvements: Remove surfacing and pavements, including bases for pavements. Remove wood headers, posts, poles, fences, and other work as specifically indicated. Removal of abandoned underground pipe(s) or conduit(s) which interferes with construction is included under this section.

H. Disposal of Waste Materials: Burning of combustible cleared and grubbed materials is permitted providing the Contractor obtains such permits and approvals required by state, county, and local authorities. Remove all waste materials and unsuitable and excess topsoil from Owner's property, and legally dispose of it.

9.16.2 Site Excavation and Grading

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation complete of all operations in connection with excavation, construction of fills, borrow, rough grading, finish site grading and disposal of excess material as shown on the drawings and as specified in accordance with provisions of the contract drawings and completely coordinate with that of all other trades.

Work included within the project consists of but is not limited to the following:

- Excavations for Booster Pump Stations.
- Excavations for Elevated Tank Foundation System.
- Excavations for water main installation.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.

Unclassified Excavation: Remove and dispose of rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by the Engineer. All excavation on this project shall be considered as unclassified.

B. Site Grading: Plans indicate both existing grade and finished grade required for construction of project. The Contractor shall stake out all units, structures, piping, roads, parking areas and walks and establish their elevations and perform all other layout work required. Replace property corner markers to original location if disturbed or destroyed.

It shall be the Contractor's responsibility to maintain existing utility lines (either overhead or underground), sidewalks, and pavement designated on drawings, shown or mentioned in specifications free of damage. For any item unknown or not properly located inadvertently damaged shall be repaired to original condition. Notify the Engineer and Owner of said utility at once so that emergency repair may be made.

During construction, shape and drain embankment and excavations. Maintain ditches and excavations to provide drainage at all times. Protect graded areas against action of elements prior to acceptance of work. Reestablish elevations and slopes where settlement or washing may have occurred.

C. Construction of Embankments and Fills: Construct embankments and fills at locations shown on plans to lines of grade indicated on drawings. Completed fill shall correspond to shape of typical cross section or contour shown on plans whichever method is used to show shape, size, and extent of line and grade of completed work.

Provide only fill material which is free from roots, organic matter, trash, frozen material, and stones having a maximum dimension greater than six (6) inches. Insure that stones larger than four (4) inches, maximum dimensions, are not placed in upper six (6) inches of fill or embankment. Do not place materials in layers greater than eight (8) inches of loose thickness. Place layers in horizontally and compact each layer prior to placing additional fill.

Compact by sheep foot rollers, pneumatic rollers, vibrators or other equipment approved by Engineer. Add moisture to or dry by aeration each layer as necessary to meet requirements of compaction. Do not place materials in embankments or fills which exceed optimum moisture content by 5 percent or are 3 percent below optimum moisture content for the material.

Under structures & roadways compact to density not less than 95 percent maximum dry density as measured by AASHO Method T99.

Under other embankments and fills, compact to not less than 90 percent of maximum dry density as measured by AASHO Method T99. (ASTM D698)

In place moisture-density tests will be ordered to insure that all work complies with these specifications. Tests will be taken at locations determined by the Engineer. Compaction will be tested by the standard cone method, nuclear density test, or drive shoe method as required or approved by the Engineer. Tests shall be performed through recognized testing laboratory or by the Engineer and all costs to be paid by the Owner. Copies of test results will be furnished to Contractor and Engineer.

Materials not meeting specified moisture-density test requirements shall be re-compacted and re-tested at Contractor's expense.

Provide, at no extra cost, the necessary amount of approved borrow material compacted to a density equal to that obtained in the laboratory by vibration and inundation. Compact to 100 percent maximum density measured by AASHO T99. Borrow or fill cannot be obtained on site except when specifically permitted by Engineer.

9.16.3 Trenching, Backfilling and Compacting

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation complete of all operations in connection with excavation, trenching, and backfilling of underground utilities as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades. 152

Work included in the project consists of but is not limited to the following utility items:

- Installation of water distribution system.
- Installation of buried appurtenances.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.

B. Protection of Existing Utilities: Verify location and existence of all underground utilities. Omission from or inclusion of located utility items does not constitute non-existence or definite location. Secure and examine local utility records for available location data.

Take necessary precautions to protect existing utilities from damage due to any construction activity. Repair all damages to utility items at sole expense. Assess no cost to Owner, Engineer, or auxiliary party for any damages.

Avoid surcharging ditch banks by placing excavated material a sufficient distance back from edge of excavation to prevent slides or caving. Maintain and trim excavated materials in such a manner to be as little inconvenience as possible to public and adjoining property owners.

Provide full access to public and private premises, to fire hydrants, at street crossings, sidewalks and other points as may be designated by the Engineer to prevent serious interruption of travel.

C. Unclassified Excavation: Remove and dispose of rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by the Engineer. All excavation on this project shall be considered as unclassified.

D. Trench Excavation: Unless given permission to do otherwise, excavate trenches by open cut method to depth shown on plans and necessary to accommodate the work. Permission may be granted for tunnel work for crossing under crosswalks, driveways or existing utility lines; however, such tunnels are limited to ten (10) feet in length.

Open only the length of trench at one time allowed by the Engineer. Do not open more than 400 lineal feet trench at one time. Failure to comply may necessitate shutdown of entire project until backfilling is performed.

Observe the following trenching criteria:

1. Trench size: Excavate only sufficient width to accommodate free working space. In no case shall trench width at the top of pipe or conduit exceed outside diameter of utility service by following dimensions:

Outside Diameter of Utility Service	Excess Dimension
33 inches and less	18 inches
more than 33 inches	24 inches

Cut trench walls vertically from bottom of trench to one (1) foot above the top of pipe, conduit, or utility service.

2. Dewatering: Keep trenches free of water. Include cost of dewatering in original bid. No additional remuneration for this item is permitted.

3. Sheeting and Bracing: Brace and sheet trenches as soil conditions dictate and in full observation of OSHA requirements. Do not remove sheeting until backfilling has progressed to a stage that no damage to piping, utility service, or conduit will result due to removal. 153

E. Preparation of Foundation For Pipe Laying: Exercise care to avoid excavations below established grade where firm earth conditions exist. If over-excavation occurs, backfill in 6-inch lifts and thoroughly compact with pneumatic tampers. In case of rock excavation, carry excavation a minimum of 12 inches below established grade and backfill to grade with suitable earth or sand. Material used shall be free of rocks, roots, sod or organic matter and shall be firmly compacted. Form bell holes in trench such that only the barrel of pipe is firmly supported by bedding material.

F. Backfilling: Use only backfill material for trenches which are free from boulders, large roots, sod, other vegetative or organic matter, and frozen material. Hand or pneumatic tamp backfill under and around pipe up to 24 inches above top of pipe in lifts not exceeding 8 inches loose thickness. Backfill and compact remainder of trench in 8-inch lifts to density specified.

Perform mechanical tamping evenly on both sides of pipe to top of excavation or to a depth such that pipe will not be injured by subsequent method of compaction used to achieve required density. Exercise extreme care in backfilling operations to avoid displacing pipe joints either horizontally or vertically and avoid breaking the pipe. Water ponding for backfill consolidation is not permitted.

G. Compaction: Compact all trench backfill in areas under roads, parking areas and sidewalks as directed by Engineer to a density of 95 percent of maximum dry density (STANDARD PROCTOR) as determined by AASHTO Method T99 (ASTM D-698). In locations where trench will not be under paved areas or roads but is inside, Department of Transportation rights-of-way, compact trench backfill to a density equal to its density before disturbance or 95 percent maximum dry density (STANDARD PROCTOR), whichever is less. In all locations not covered above, compact trench backfill to a density equal to its density before disturbance or minimum 90 percent of maximum dry density (STANDARD PROCTOR), as determined by AASHTO Method T99 (ASTM D-698) whichever is less.

H. Testing: Perform in-place moisture-density tests as ordered by Engineer to insure trench backfill complies with requirements. Tests shall be performed through recognized testing laboratory and all costs to be paid by the Owner. Copies of test results will be furnished to Contractor and Engineer. Where backfill compaction does not pass moisture-density test requirements and after backfill has been removed as directed by Engineer and situation corrected, additional tests will be directed until compaction meets or exceeds requirements. The Contractor shall pay the cost of any additional testing required as a result of his failure to meet minimum compaction requirements.

I. Pavement Cuts: All pavement cuts shall be made to true line by a method acceptable to the Engineer and the pavement removed just prior to the trenching operation. The Contractor will be allowed to excavate no more trench width than the pipe outside diameter plus 18 inches for pipe up to 33 inches in diameter and 24 inches for pipe over 33 inches in diameter, in all paved areas. The pavement will be trimmed an additional twelve inches (12") beyond the trench edge to give firm bearing for the patching operations.

The Contractor shall backfill all trenches to a point ten inches (10") below the existing pavement and then backfill with crushed stone flush with the existing pavement. It shall be the Contractor's responsibility to maintain all pavement cuts in good order until asphaltic patching is completed. At the time of patching, all broken down, ragged edges shall be trimmed to true line.

It shall be the contractor's responsibility to provide drag boxes, ditch jacks, sheeting, etc., as required to maintain the trench width as specified. The Owner will pay only for the width of pavement removal as specified above.

It is intended that no section of streets or road (3,000 linear feet of line) shall be left in an incomplete condition for a period in excess of thirty days. This completion shall include all phases of work on the lines to be constructed in the area of the section, including trenching, placing pipe, backfilling, setting valves, hydrants, and fittings, installing house services as required preparation for paving repair, repair of paving, grassing and clean-up for delivery of the completed section to the Owners. This requirement shall be adhered to in its entirety unless waived in writing by the Owners through the Engineers. Flushing, testing and disinfection maybe delayed until a sufficient amount of line is ready. Failure to comply with this condition for more than 30 days will result in reduction of payment to the contractor.

9.16.4 Pipe Laying – Pressure Pipe

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation complete of all pressure pipe construction as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

B. Quality Standards: Procedures for handling, laying, protection, and use of pipe shall be in accordance with the pipe manufacturer's recommendations and these specifications.

C. Submittals: The Contractor is to submit to the Engineer the manufacturer's name and type of material for all materials used on this project. Such materials shall meet with the approval of the Engineer. If the materials submitted do not meet with the approval of the Engineer, the Contractor is to submit other types and makes that may be approved.

D. Product Delivery, Storage, and Handling: Units shall be delivered, handled, and maintained in a manner to avoid damage to the pipe.

E. Materials: Refer to the approved plans and the material specifications in Chapter 9 for the materials specified.

F. Clearing Rights-of-Ways: When piping system to be constructed under this project is outside of the streets rights-of-way, the rights-of-way are to be cleared by the Contractor to a width satisfactory for the installation and the cost of same is to be included in the price bid for the line in place. No extra allowance will be made for rights-of-way clearing.

G. Installation: The work included under this article consists of but is not limited to furnishing and installing piping systems used for the purposes of carrying fluids under pressure and shall include pressure testing. Disinfection shall be included for potable water lines.

H. Tapping Sleeves: All tapping sleeves installed in Harnett County's existing water distribution system shall be constructed with stainless steel material and meet the requirements established in AWWA Standard C223-02. Stainless steel fabricated tapping sleeves shall be Romac model SST or approved equal made from stainless steel material that meets or exceeds the requirements of ANSI/AWWA C220. Cast Iron tapping sleeves are not permitted to be used in the Harnett County water distribution system. Tapping flanges for stainless steel fabricated tapping sleeves shall meet or exceed the requirements of ASTM A240, ASTM A743/A743M, or ASTM A744/A744M.

The tapping sleeve shall be installed per the manufacturer's installation instructions provided with the fabricated tapping sleeve. The manufacturer's instructions must be followed regarding support of the valve and the tapping machine during the tapping procedure. The contractor shall hydrostatically test the seal between the gasket of the tapping sleeve on the pipe of the existing water main and the gate valve before the tapping machine may be set up to perform the tap. The contractor may tap into the existing water main only after the hydrostatic pressure test has been completed with satisfactory results. For personal safety reasons, do not use a compressible fluid medium (such as air) to check for water tightness.

The HCDPU Utility Construction Inspector must witness the hydrostatic testing on the tapping sleeve and valve assembly as well as the tapping procedure on the existing water main. The coupon removed from the existing water main when the water line is tapped shall be given to the HCDPU Utility Construction Inspector. The HCDPU Utility Construction Inspector shall return the coupon to the HCDPU Engineer for a visual analysis. Additional non-destructive analysis may be performed by the HCDPU Engineer on the coupon to determine the condition of the existing water main. Coupons removed from AC pipe shall be sealed in a plastic bag to reduce the potential for fraying or dispersal of asbestos material.

I. Pipe & Fittings: Materials at all times shall be handled in such a manner as to protect them from damage. Pipe and fittings should be handled with mechanical equipment at all times that the work site will permit. At no time shall pipe and fittings be dropped or pushed into ditches. Pipe and fitting interiors shall be protected from foreign matter and shall be inspected for damage and defects prior to installation. In the event foreign matter is present in pipe and fittings, it shall be removed before installation.

All pipe shall be in manufacturer's full nominal lengths and shall have a minimum of (36") thirty-inches of cover. Pipe shall be laid on true lines as directed by the Engineer. Ditches are to be dug of sufficient width to adjust the alignment. Bell holes shall be dug at each joint to permit proper making of the joints. The pipe shall be laid and adjusted so that the alignment with the next succeeding joint will be centered in the joint and the entire pipeline will be in continuous alignment both horizontally and vertically. Pipe joints shall be fitted so that a thoroughly watertight joint will result. All joints will be made in conformance with the manufacturer's recommendations for the type of joint selected. In no case shall two types of pipe be used in this project, except where ductile or cast iron pipe is required. All transition joints between different types of pipe shall be made with transition couplings approved on shop drawings showing the complete assembly to scale.

J. Existing Utilities: Prior to beginning construction, the Contractor will contact local utility companies and verify the location of utilities. When existing utilities are in conflict with construction, they shall be exposed prior to beginning construction to prevent injury to the utilities.

K. Trenching Along Roadways and Unpaved Areas:

In paved areas, the Contractor shall compact the backfill as specified to a point 10" below the pavement surface and will then backfill with crushed stone, as shown on the plans.

All pavement cuts will be patched no later than two (2) days after backfilling. The unpaved areas of the rights-of-way shall be grassed as described in a later article of these specifications when disturbed by this work.

For work along highways, no more than 3,000 feet of disturbed shoulder shall be unseeded at any time. Ditches shall be maintained by the Contractor in good condition until the project is accepted by the Owners.

Any unpaved side road, dwelling entrance road, commercial entrance, or any other area presently stabilized by use of rock material shall be protected from erosion during construction and shall be stabilized by use of crusher run stone after backfilling. This stone stabilization shall be approximately four (4) inches thick unless otherwise directed by the Engineer. The Contractor shall submit his price for this stone placed as described under "Stone for Shoulder Stabilization" in the Proposal. Stone used in the repair of paved roads and streets shall be paid for separately and shall be included in the proposal under "Stone for Pavement Repairs."

The Contractor shall schedule his work to cause the least inconvenience to the public and will maintain traffic at all times. If the work shall require the existing water mains to be temporarily closed or shut off, then the contractor shall coordinate the work activity with the HCDPU staff and provide at least 48 hours to all existing water customers that will be affected by the outage. The contractor will be responsible for properly safeguarding the public against accidents and shall save harmless the County or developer/owner and shall assume responsibility for any suits or actions for damages of other law suits, which may be instituted against the County or developer/owner because of any incident arising from the construction. The contractor shall follow all traffic control measures using NCDOT work Zone methods in accordance with all NCDOT requirements.

Excavated materials shall be placed on one side of the trench; and when backfilling is completed, all excess materials will be hauled off and the work shall be left in an acceptable manner. Excavated materials will never be piled beyond the centerline of the road or street. Attention is called to the fact that under no condition shall the work be accepted until completed and finished in a workmanlike manner. Barriers shall be placed and lights furnished by the Contractor as directed by the Engineers and as covered elsewhere in these specifications.

The contractor shall leave no block of streets (3,000 linear feet of line) in an incomplete condition for a period in excess of thirty days. This completion shall include all phases of work on the lines to be constructed, including trenching, placing pipe, backfilling, setting valves, hydrants and fittings, installing house services as required, testing, preparation for paving repair, repair of paving and clean-up for delivery of the completed section to the Owners. This requirement shall be adhered to in its entirety unless waived in writing by the Owners through the Engineers. The intent shall be to place the section of line into service as soon as possible. It shall be required to begin construction at the connection to the existing water system in order that water for testing, flushing and placing the line into service can be brought along with the construction. Failure to construct the project in this matter (unless otherwise impossible) will result in reduction in the amount of partial pay requests that the contractor may submit on the line section in question.

L. Pressure Testing: After installation and backfilling of the pressure mains, each section (as required by the Engineers) of the pipeline system shall be subject to a hydrostatic pressure test equal to 200 psig. Before applying the specified test pressure, all piping shall be thoroughly flushed and all air shall be expelled from the pipe. If outlets are not available at high places, the Contractor shall make the necessary taps at points of highest elevations before the test is made. The test pressure shall be maintained in the section tested for a period of three (3) hours. Allowable leakage in the three (3) hour period shall not exceed the following:

PIPE DIAMETER (INCHES)	LEAKAGE PER 1,000 FEET (GALLONS PER HOUR)
2	0.43
4	0.85
6	1.28
8	1.70
12	2.56
16	3.40
20	4.24
24	5.10

Tests may be made of isolated portions of such piping as will facilitate general progress of the installation. Any revisions made in the piping systems will subsequently necessitate retesting of such affected portions of the piping systems.

When water service is available from the Owner, reasonable amounts of water will be provided the Contractor for line flushing and testing at no cost. The availability of water for this purpose is subject to the Owner's own needs or requirements. Water loss, as the result of line breakage, blocking movement, blow outs, or other reasons directly attributable to the Contractor's work, shall be paid for by the Contractor at the Owner's prevailing rates.

The hydrostatic test shall be conducted by the Contractor under the direct observation HCDPU Utility Construction Inspector and the Professional Engineer. Any defective material causing excessive leakage shall be repaired or replaced and the test repeated until satisfactory results are achieved by the pipe or pipe section holding the pressure for at least two (2) hours.

M. Disinfection:

After pressure testing, the new water lines are to be disinfected in accordance with AWWA All new, cleaned or repaired water mains shall be disinfected in accordance with AWWA Standard C651-05 and as specified herein. The water lines are to be flushed thoroughly to remove all dirt and debris which may have collected in the line. After flushing has been completed, the pipelines shall be tapped on top at a point furthest from the point that the lines are to be filled with water. The valve at the end of the line shall then be closed, and the valve between the new water line and the Municipal Water System opened slightly to allow the water to enter the new pipe slowly.

Chlorine is then to be applied under pressure by an ejector pump (or equal) to the water entering the new pipeline. Chlorine will be added in sufficient quantities to give an overall chlorine residual to the water of at least fifty (50) parts per million. The pipeline is to be completely isolated from the system by closed valve(s) and the chlorinated water allowed to remain in the line for at least twenty-four hours. At the end of this period, the pipeline is to be thoroughly flushed until no evidence of chlorine exists as determined by the Ortho-Tolidine Test.

These specifications still include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains. Three methods of disinfecting newly constructed water mains are as follows: the tablet method, the continuous-feed method, and the slug method. The HCDPU prefers the contractor to use the continuous-feed method to achieve an initial concentration of at least 50 mg/l chlorine within the entire length of the pipe(s) and maintain a concentration of at least 25 mg/l after 24 hours contact time.

1. Initial Flushing
All new water lines extended from Harnett County‟s existing water distribution system shall be thoroughly flushed to remove foreign matter, dirt and debris that may have entered the pipe during the construction process. Preliminary flushing removes light particulates from the main but not from the pipe-joint spaces. The initial flushing of any water line shall be conducted to maintain a flushing velocity of at least 2.5 feet per second. Once the initial flushing procedures have been completed and the pipe is clear of foreign matter, dirt and debris, then the contractor shall sterilize the pipe using the continuous feed method for water lines.

Flushing and cleaning shall be the responsibility of the contractor. The contractor shall pump dry and dispose of all extraneous ground water and other sand gravel and foreign objects within the water main. Such material shall not be flushed into the existing operating sewer mains, pump stations or pertinent facilities. Flushing of water main lines under construction into sewer main lines of the HCDPU is prohibited. Water for flushing and cleaning shall be provided by the HCDPU upon payment of the appropriate fees for a fire hydrant meter in keeping with HCDPU established standards rates and regulations. The water mains shall be flushed at the end of the blow off.

2. Chlorination Methods
The chlorine concentration is uniform throughout the main when using the continuous-feed method. The slug method is suitable for use in large-diameter mains where the volume of water makes the continuous-feed method impractical and difficult to achieve for short attachments. The slug method results in appreciable savings of chemicals used to disinfect long, large-diameter mains. Also, this method reduces the volume of heavily chlorinated water to be flushed to waste. The continuous-feed or slug methods should be used with gas chlorination only when properly designed and constructed equipment is available; makeshift equipment is not acceptable when liquid-chlorine cylinders are used.

The continuous-feed method consists of placing calcium hypochlorite granules in the main during construction (optional), completely filling the main to remove air pockets, flushing the completed main to remove particulates, and filling the main with potable water. The potable water shall be chlorinated so that after a 24-hr holding period in the main there will be a free chlorine residual of not less than 10 mg/L.

At the option of the contractor, calcium hypochlorite granules shall be placed in pipe sections to provide a strong chlorine concentration in the first flow of flushing water that flows down the main. In particular, this procedure is recommended when the type of pipe is such that this first flow of water will flow into annular spaces at pipe joints. Before the main is chlorinated, it shall be filled to eliminate air pockets and flushed to remove particulates. The flushing velocity in the main shall not be less than 2.5 ft/sec (0.76 m/sec) unless the purchaser determines that conditions do not permit the required flow to be discharged to waste. Note that flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity and pigging of the main may be required.

In accordance with T15A NCAC 18C .1003 or latest NCDENR PWS version, the waterline shall be disinfected by continuous feed disinfection method.

3. Final Flushing
After the applicable retention period, heavily chlorinated water should not remain in prolonged contact with pipe. In order to prevent damage to the pipe lining or to prevent corrosion damage to the pipe itself, the heavily chlorinated water shall be flushed from the main fittings, valves, and branches until chlorine measurements show that the concentration in the water leaving the main is no higher than that generally prevailing in the distribution system or that is acceptable for domestic use. The environment to which the chlorinated water is to be discharged shall be inspected. If there is any possibility that the chlorinated discharge will cause damage to the environment, a neutralizing chemical shall be applied to the water to be wasted to thoroughly neutralize the residual chlorine. Where necessary, federal, state, local, or provincial regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water. Thorough consideration should be given to the impact of highly chlorinated water flushed into the waste environment. If there is any question that damage may be caused by chlorinated-waste discharge (to fish life, plant life, physical installations, or other downstream water uses of any type), then an adequate amount of reducing agent should be applied to water being disposed of in order to thoroughly neutralize the chlorine residual remaining in the water

4. Bacteria Testing of Water Samples
The purpose of chlorination is to clean and disinfect water lines, resulting in an absence of coliforms as confirmed by laboratory analysis. All water samples collected for testing must be analyzed in a state certified laboratory and for this reason all water samples will be tested by the HCDPU laboratory.
Water samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate and they shall be tested for bacteriological (chemical and physical) quality in accordance with *Standard Methods for the Examination of Water and Wastewater*; and shall show the absence of coliform organisms; and, if required, the presence of a chlorine residual. Turbidity, pH, and a standard heterotrophic plate count (HPC) test may be required at the option of the county because new material does not typically contain coliforms but does typically contain HPC bacteria.

After flushing the line, the Contractor shall be responsible to furnish sample points at various points along the line under the direct observation HCDPU Utility Construction Inspector and the Professional Engineer. While the Contractor is responsible to furnish sterilized bottles and take water samples for testing the HCDPU Utility Construction Inspector will generally furnish sterilized bottles and take water samples to the HCDPU laboratory for testing and bacteria analysis. The HCDPU laboratory is a state certified laboratory and this service is free of charge at this time, but subject to change if lab fees become necessary to maintain the state certified laboratory.

A minimum of three samples shall be taken in any instance. The Contractor may send additional samples to an approved laboratory for bacteriological analysis at the contractor’s expense. If the analysis reveals that no bacteria is present, the line or lines may be approved to be placed into service upon notification of the Engineer, and Final Approval by the North Carolina Department of Environment and Natural Resources – Division of Environmental Health, Public Water Supply Section (NCDENR-DEH, PWSS).

At least one set of water samples shall be collected from every 1,200 ft (366 m) of the new water main, plus one set from the end of the line and at least one set from each branch. The sampling pipe must be dedicated and clean and disinfected and flushed prior to sampling. A corporation cock may be installed in the main with a copper-tube gooseneck assembly. After samples have been collected, the gooseneck assembly may be removed and retained for future use. The gooseneck assembly shall be stored in a clean, dry area between uses to avoid potential contamination from the assembly entering the water samples. Water samples shall have no coliforms present and the HPC is less than 500 cfu/mL.

5. Repeat Disinfection Procedures Until All Water Samples Test Negative For Coliform
If test results from the lab indicate a measured HPC greater than 500 colony-forming units (cfu) per mL for any water sample then, flushing and disinfection procedures should be resumed and continued for another 24 hour contact period. Following the second final flushing procedure, another set of water samples shall be collected and analyzed for the presence of coliform and HPC and the disinfection process shall be repeated until a set of water samples have no coliforms present and the HPC is less than 500 cfu/mL. The record of compliance shall be the bacteriological test results certifying that the water sampled from the new water main is free of coliform bacteria contamination and is equal to or better than the bacteriologic water quality in the distribution system. The HCDPU laboratory will forward all test results to the HCDPU Engineer to verify the disinfection process is complete and the results are satisfactory.

N. Protecting Open Pipelines: All water mains installed under this contract shall be thoroughly blocked against access to the pipe of any water from extraneous sources, any vermin, animals, mud, silt or other deleterious materials by installation of plugs designed for the purpose at every pipe end at all times when the pipe ending is not attended by contractor personnel.

O. Relation of Water Mains to Sewers: The Contractor shall adhere to the location of the water and sewer lines as shown on the plans (if applicable). If conditions change in the field that require relocation of either water or sewer mains, the Contractor shall insure that the water main is laid at least 10 feet laterally from existing or proposed sewers. If the 10 foot lateral separation is not possible then the water main shall be laid in a separate trench with the bottom of the water main at least 24 inches above the top of the sewer. If neither the 10 foot lateral or 24 inch vertical separation is possible then the water and sewer lines shall both be constructed of ductile iron pipe (class 50 w/pressure tight joints) for a distance of 10 feet on each side of the point of crossing and the state minimum 18 inch vertical separation shall be maintained.

9.16.5 Boring and Jacking Under Highways

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation to complete all boring and jacking under highways as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades. The contractor shall be responsible for the work performed by a subcontractor to meet all NCDOT requirements and satisfy all requirements outlined herein these specifications. The contractor shall be responsible to repair any and all damage to existing street pavement or the right-of-way caused by the boring the jacking procedure. The areas where the contractor shall dig the bore pits shall be restored to the same condition before the bore and jacking operation started leaving the right-of-way in as good or better condition once the work is complete.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete and compatible installation shall be furnished and installed as part of this work.

B. Quality Standards: Procedures for boring and jacking shall be in accordance with the best accepted practice of the industry and these specifications.

C. Submittals: The Contractor shall submit to the Engineer the manufacturer's name for all materials to be used in this project, along with such other information the Engineer may request.

D. Product Delivery, Storage, and Handling: Units shall be delivered, stored and handled in such a manner to avoid damage to the material.

E. Job Conditions: Verify all grade and alignment prior to setting up boring rig. Installation assumes responsibility for performance.

F. General Requirements: Lines installed under major highways shall be performed by boring under the highway or tunneling as may be required by the North Carolina Department of Transportation. Where boring under pavement is required by the Department of Transportation, the Contractor will be paid the unit price bid in the Proposal for each linear foot of pipe so placed of the type bid upon in the proposal.

In placing the pipe, any annular space exceeding one-quarter inch in width between casing and tunnel shall be fitted with 1:2 Portland cement mortar grout, pumped into the space to form a tight fit between casing and tunnel walls. Cost of grouting shall be an integral part of the price submitted in the Proposal for the type and size pipe, "Boring Under Highways" required by the installation.

The Engineer may require "Boring and Jacking" under objects or pavement not indicated on the plans but required in the best interest of the Owners, in which case the payment for each linear foot required will be made at the unit price given in the Proposal for "Boring Under Highways".

Where North Carolina Department of Transportation (NCDOT) requires casings to be installed at primary highway crossings, the Contractor shall install the casings in accordance with the following requirements:

The Contractor shall be required to notify the Department of Transportation on the contemplated construction and secure the necessary permit for performing the work.

G. Installation: All work on boring and/or casing under highways shall be under the supervision of the District Engineer of the Department of Transportation or his authorized representative who shall be notified at least five (5) days before actual work or installation begins. Pipelines shall be installed under highways by boring and jacking where shown on the plans.

H. Carrier Pipe: Carrier line pipe and joints under primary highways shall be of approved material and construction satisfactory to the District Engineer of the Department of Transportation. Pipelines operating under pressure must be of a material and type capable of withstanding the internal stresses generated in the lines. Joints may be welded, screwed or mechanical type.

I. Casing Pipe for Primary Highways: The inside diameter of casing pipe for carrier pipe less than 6 inches in diameter shall be not less than 2 inches greater than the largest outside diameter of the carrier pipe, joints or couplings and not less than 4 inches greater for carrier pipe 6 inches and larger in diameter. It shall, in all cases, be great enough to afford easy removal of the carrier pipe without disturbing the casing pipe or roadbed.

The casing pipe must be capable of withstanding highway loadings and must be so constructed as to prevent leakage of any matter throughout its length, except in cases where the ends are not sealed. Casing shall be installed in a manner to prevent the formation of a waterway under the highway. It must have an even bearing throughout its length, except in cases where the ends are not sealed. Casing shall be installed in a manner to prevent the formation of a waterway under the highway. It must have an even bearing throughout its length and slope to one end.

If installed by the open trench method ductile iron pipe with restrained joints may be used with approval by the NCDOT, the Professional Engineer and the HCDPU Engineer. Sizes 12 inches and under shall be not less than Class 50. Sizes 14 inches through 48 inches shall be not less than Class 51 or as shown on plans or directed by the Engineer.

Standard weight (Schedule 40) wrought steel or wrought iron pipe having wall thickness as listed below may be used as casing pipe in sizes 8 inches and smaller.

WROUGHT STEEL DIAMETER OF PIPE (Inches)	WROUGHT IRON WALL THICKNESS (Inches)	WALL THICKNESS (Inches)
2-1/2	.203	.208
3	.216	.221
3-1/2	.226	.231
4	.237	.242
5	.258	.263
6	.280	.286
8	.322	.329

Steel pipe in sizes 8 inches and larger manufactured from steel having minimum yield strength of 35,000 psi and having minimum permissible wall thickness as listed below may be used as casing pipe. Adjust the thickness for other grades of pipe, except that the wall thickness shall be not less than .3125 (5/16") inch:

DIAMETER OF PIPE (Inches)	MINIMUM WALL THICKNESS (Inches)
12	.188
16	.250
18	.250
DIAMETER OF PIPE (Inches)	MINIMUM WALL THICKNESS (Inches)
20	.250
24	.250
30	.312
36	.375

J. Depth of Casing Pipe: The depth from surface of roadway to top of pipe at its closest point shall be not less than 3 feet.

K. Protection at Ends of Casing Pipe: Where ends of casing are below ground, they shall be suitably protected against the entrance of foreign material but shall not be tightly sealed. Where the ends of the casing are at or above ground surface and above high water level, they may be left open, provided drainage is afforded in such a manner that leakage will be conducted away from highway surface or structures.

L. Shoring of Ditches: Shoring shall be done in a neat, safe and workmanlike manner so as to prevent any cave-ins or settlement of the roadway and so as not to endanger any personnel working in the ditch. Contractor shall be required to provide shoring of pits, trenches and other excavation in accordance with the latest requirements of the North Carolina Department of Transportation and the Federal Occupational Health and Safety Act.

M. Length of Casing Pipe: Casing pipe shall be of a length as determined to be necessary by the Department of Transportation District Engineer and the Project Engineer.

N. Removal of Casing Pipe: In the event that an obstruction is encountered during the dry boring operation, the auger and spiral welded steel pipe encasement are to be withdrawn and the void is to be completely filled with grout at 25 psi pressure before moving to another boring site.

O. Payments: The Contractor shall be paid the unit price bid in the proposal for the size of casing in place complete under the primary highways, including the furnishing of all labor, tools, equipment, and materials required for the various installations. Water mains through casing will be paid for at the unit price bid in addition to the price paid for casings under the highways.

9.16.6 Horizontal Directional Boring Under Highways

A. General:
Directional boring is a method of trenchless construction using a surface launched steerable drilling tool controlled from a mobile drilling frame, and includes a field power unit, mud mixing system and mobile spoils extraction system. The drilling frame is sited and aligned to bore a pilot borehole that conforms to the planned installation of the main. The drilling frame is set back from an access pit that has been dug (typically at the location of a proposed manhole or other appurtenance) and a high-pressure fluid jet tool head that uses a mixture of bentonite clay and water is launched. Pits are normally dug at the start point and endpoint of the proposed pipe installation and are used to align the tool head, attach other equipment, and to collect and remove excess spoils. Using an electronic guidance system, the tool head is guided through the soil to create a pilot borehole. Upon reaching the endpoint joint, the tool head is removed and a reamer with the product pipe attached is joined to the drill string and pulled back through the borehole. In large diameter installations, pre-reaming of the borehole will usually be done prior to attaching the product pipe for the final pullback. A vacuum spoils extraction system removes any excess spoils generated during the installation. The connections, manholes or other appurtenances are then completed at both the start point and endpoint locations and the surface restored to its original condition.

B. Site Conditions for Directional Borings
Drilling operations must not interfere with, interrupt or endanger surface and activity upon the surface. Contractor must comply with all applicable jurisdictional codes and OSHA requirements. When rock stratum, boulders, underground obstructions, or other soil conditions that impede the

progress of drilling operations are encountered, the Contractor and Engineer shall review the situation and jointly determine the feasibility of continuing drilling operations.

C. Qualifications for Directional Boring Contractors
Directional boring Contractors will have actively engaged in the installation of pipe using directional boring techniques for a minimum of three years. Field supervisory personnel employed by the Directional Boring Contractor will have at least three years' experience in the performance of the work and tasks. Submit documentation indicating experience. Information must include, but not be limited to, date and duration of work, location, pipe information (i.e., length, diameter, depth of installation, pipe material, etc.), project owner information, (i.e., name, address, telephone number, contact person), and the contents handled by the pipeline (water, wastewater, etc.). Submit a list of field supervisory personnel and their experience with directional boring operations. At least one of the field supervisors listed must be at the site and be responsible for all work at all times when directional boring operations are in progress. Directional boring operations will not proceed until the resume(s) of the Contractor's field supervisory personnel have been received and reviewed by the Engineer.

D. Submittal Drawings for Directional Boring
The Directional Boring Contractor shall provide working drawings and written procedure describing in detail the proposed method of installation. This will include, but not be limited to, size, capacity and setup requirements of equipment; location of drilling and receiving pits; dewatering if applicable; method of fusion and type of equipment for joining pipe; type of cutting tool head; and method of monitoring and controlling line and depth. If the Contractor determines that modifications to the method and equipment as stated in the submittal are necessary during construction, the contractor will submit a plan describing such modifications, including the reasons for the modification.

E. Drilling Fluid:
Drilling Fluid for Directional Bores will be an inert fluid mixture of water and bentonite clay.

F. Conformance:
Directional Boring shall conform to ASTM F1962. The Contractor will furnish all labor, components, materials, tools and appurtenances necessary or proper for the performance and completion of the contract. The Engineer shall be notified immediately if any obstruction is encountered that stops the forward progress of drilling operations.

G. Preparation:
Excavate required pits in accordance with the working drawings. The drilling procedures and equipment shall provide protection of workers, particularly against electrical shock. As a minimum, grounding mats, grounded equipment, hot boots, hot gloves, safety glasses and hard hats shall be used by crewmembers. The drilling equipment shall have an audible alarm system capable of detecting electrical current. Removal of trees, landscaping, pavement or concrete shall be performed as specified.

H. Equipment:
The drilling equipment must be capable of placing the pipe within the limits indicated on the contract plans. Directional boring equipment shall consist of a surface launched steerable drilling tool controlled from a mobile drilling frame, and include a field power unit, mud mixing system

and mobile spoils extraction system. The number of access pits shall be kept to a minimum and the equipment must be capable of boring the following lengths in a single bore.

I. Safety Equipment:
During drilling operations all equipment shall be effectively grounded and incorporate a system that protects operating personnel from electrical hazards. The system shall be equipped with an audible alarm that can sense if contact is made with an energized electric cable. Proper operation of the alarm system will be confirmed prior to the drilling of each tunnel. All equipment will be connected to ground with a copper conductor capable of handling the maximum anticipated fault current. Crew members operating drilling equipment and handling rods will do so while standing on grounded wire mesh mats, ensuring that all equipment is grounded, and wearing hot boots, hot gloves, safety glasses and hard hats. Crewmembers operating handheld locating equipment will wear hot boots.

J. Pilot Hole Boring / Adjustments / Restarts
The entry angle of the pilot hole and the boring process will maintain a curvature that does not exceed the allowable bending radii of the product pipe. The Contractor shall follow the pipeline alignment as shown on the Drawings, within the specifications stated. If adjustments are required, the Contractor shall notify the Engineer for approval prior to making the adjustments.

K. Product Pipe Installation:
After the pilot hole is completed, the Contractor shall install a swivel to the reamer and commence pullback operations. Pre-reaming of the tunnel may be necessary and is at the option of the Contractor.

1. Reaming diameter will not exceed 1.5 times the diameter of the product pipe being installed.

2. The product pipe being pulled into the tunnel will be protected and supported so that it moves freely and is not damaged by stones and debris on the ground during installation. The drilling fluid should remain in the tunnel to ensure the stability of the tunnel, reduce drag on the pulled pipe, and provide backfill with the annulus of the pipe and tunnel.

Pullback forces will not exceed the allowable pulling forces for the product pipe.

The Contractor shall allow sufficient lengths of product pipe to extend past the termination point to allow connections to the diffuser assembly. Pulled pipe will be allowed 24 hours of stabilization prior to making tie-ins. The length of extra product pipe will be at the Contractor’s discretion.

The contractor shall allow at a minimum of 20 linear feet of directional-drilled pipe on each end of the installation. The additional pipe lengths shall be on a parallel plane with the existing grade at the point of connection to the Ductile Iron or PVC main.

L. Cleanup and Disposal of Drilling Fluid:
The Contractor shall maintain the work site in a neat and orderly condition throughout the period of work and after completing the work at each site, remove debris, surplus material and temporary structures erected by the Contractor. The site shall be restored to a condition equal to the existing condition prior to being disturbed. Disposal of excess drilling fluid and spoils will be the responsibility of the Contractor who must comply with all relevant regulations, right-of-way, work space, permits and encroachment agreements. Excess drilling fluid and spoils will be disposed at

an approved location. The Contractor is responsible for transporting all excess drilling fluid and spoils to the disposal site and paying any disposal costs. Excess drilling fluid and spoils will be transported in a manner that prevents accidental spillage onto roadways. Excess drilling fluid and spoils will not be discharged into sanitary or storm drain systems, ditches or waterways.

Drilling fluid returns (caused by fracturing of formations) at locations other than the entry and exit points will be minimized. The Contractor will immediately clean up any drilling fluid that surfaces through fracturing. Clean up of excess drilling fluid shall be accomplished by the means of mobile spoils removal equipment.

Mobile spoils removal equipment capable of quickly removing spoils from entry or exit pits and areas with returns caused by fracturing will be present during drilling operations to fulfill the requirements of paragraph "a" above. The Contractor shall not commence drilling operations without the presence of drilling fluid removal equipment. All excess drilling fluid shall be removed from the site(s) and disposed of properly.

The Contractor will be responsible for making provisions for a clean water supply for the mixing of drilling fluid. Water purchased from the HCDPU water distribution system must be metered through fire hydrant meters and paid for by the Contractor. The Contractor shall contact the HCDPU Administrative Office to obtain a fire hydrant meter and return the same to the HCDPU Administrative Office along with payment for the water used on site.

The contractor shall contain all drilling fluids from the site until such time that the excess fluid may be removed from the site by mobile spoils removal equipment. At no time shall the contractor allow excess drilling fluids to drain into water bodies such as streams, rivers, lakes, wetlands etc.

M. As-Builts
The Contractor shall provide to the Engineer a bore plan (boring log) to provide the as-built condition of the bore. This information shall include the pipe depth at intervals of 50 lf, which shall indicate the horizontal alignment with respect to a horizontal baseline.

9.16.7 Work Along Highways

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation to complete all work along highways construction as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades. ~~165~~

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

B. Quality Standards: All work within the rights-of-way of the Department of Transportation shall be governed by DOT Standard Specifications.

C. Job Conditions: The Contractor shall verify all existing conditions prior to beginning work with the rights-of-way of DOT. Any unusual conditions should be brought to the attention of the Engineer.

D. Work Along Highways: The Contractor shall be responsible for notifying the North Carolina Department of Transportation of the proposed construction, shall secure necessary permits, and shall be responsible for any damage to existing roadways by reason of his work. The Contractor will be required to replace paving cut on account of this work. The Contractor shall also be entirely responsible for backfilling and maintaining the ditches cut along and across highways in accordance with the permits received from the North Carolina Department of Transportation and as is required by these specifications.

It will be absolutely necessary for the Contractor to schedule on-the-site inspection prior to beginning work at highway bridges and/or box culverts by contacting the Head of Bridge Maintenance.

Lines installed under major highways shall be performed by boring under highway or tunneling as may be required by the North Carolina Department of Transportation.

Where lines to be installed by the open-cut method pass under culverts on the Department of Transportation right-of-way, the Contractor shall fill the void from the bottom of the line to the bottom of the culvert with pea gravel (DOT No. 78M). When the Contractor tunnels under culverts, any voids shall be filled with pea gravel (DOT No. 78M) or concrete as directed by the Engineer. The Contractor shall include the cost for placing this item in the appropriate lump sum or unit price item.

The Contractor shall conduct his work in accordance with the requirements of the Department of Transportation; and in particular, he shall be required to control traffic in the vicinity of the work as required by the latest revision of the North Carolina Construction and Maintenance Operations Supplement to the Manual of Uniform Traffic Control Devices (MUTCD) for Streets and Highways. This publication may be obtained from the Traffic Engineering Branch, Division of Highways, Department of Transportation, and Highway Safety. Contractor will be required to obtain and have in his possession one copy of the above-referenced publication and to comply with the requirements therein.

The use of this supplement manual does not preclude the use of the MUTCD, and it is recommended that Part VI of the MUTCD be read before attempting any construction or maintenance signing. Any conflicts found to occur between the Supplement Manual and the MUTCD shall be resolved in favor of the MUTCD.

E. Unpaved Roadways: Any unpaved road, side road, dwelling entrance road, commercial entrance, road shoulder, or any other area presently stabilized by use of rock material shall be protected from erosion during construction and shall be stabilized by use of #57 (crusher run) stone after backfilling. This stone stabilization shall not be less than approximately four inches (4") thick unless otherwise directed by the Engineer.

F. Pavement Cuts: In pavement cuts, the Contractor shall compact the backfill as hereinbefore specified and then remove compacted earth to a point ten inches (10") below the pavement surface and will then backfill with crushed stone as shown on the plans.

The Contractor shall maintain in good condition the ditch line in pavement cuts until paving is authorized to be replaced. The Contractor, upon notification from the Engineer, shall replace any and all paving cut on this project by placing a paving of similar nature to that cut to the specifications of the North Carolina Department of Transportation. 166

The Contractor will not be reimbursed for pavement damaged on the opposite side of the roadway from the construction. The Contractor shall repair and replace such damaged pavement at his own expense.

G. Service Lines: All service lines crossing highways shall be installed by boring under highway unless special permission for open cutting is obtained by the Contractor from the Division Engineer of the Department of Transportation.

9.16.8 Asphalt Paving

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation complete of all asphalt paving construction as shown on drawings and as specified in accordance with provisions of the contract documents and completely coordinated with that of all other trades.

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

B. Quality Standards: Contractors shall perform all work in accordance with the North Carolina Department of Transportation Standard Specifications for asphalt paving and these specifications.

C. Submittals: The Contractor shall submit the names of the suppliers of all materials to be used in this project.

D. Job Conditions: The Contractor shall verify suitability of sub grade prior to placing the stone base or asphaltic paving. Installation assumes responsibility for performance.

E. Materials: All suppliers and sources of materials shall be approved for use by the Department of Transportation of the State of North Carolina.

F. Stone Base Course: All work on this project will have six-inch minimum compacted thickness, except as is otherwise designated on the plans or as given in written instruction by the Engineer. CABC shall consist of one or more natural materials proportioned and blended on the area to be paved and shall meet the requirements of the N. C. Department of Transportation Standard Specifications for roads and pavements.

The contractor shall utilize the stone placed in the trench after backfilling of the line in so far as possible. Additional stone may be required to bring the minimum stone thickness up to the required depth.

Prior to placing asphalt, the surface shall be thoroughly rolled for its full length and width with a power roller or vibrating tamp to thoroughly compact the stone base. Rolling and and/or tamping shall be continued alternately until the surface is smooth and the entire base is compacted.

Irregularities or depressions developed by rolling shall be corrected by loosening the material and compacting to form a uniform surface. Along curbs, headers and walls and at places not accessible to the roller the base shall be compacted thoroughly with mechanical tampers or with hand tampers. Mechanical tamping shall be done with an approved rapid hitting mechanical tamper capable for delivering 185 pounds per square foot of tamping area per blow. Hand tampers shall weigh not less than 50 pounds with a face area of not more than 100 square inches.

G. Asphaltic Concrete: The Contractor will be required to place a surface course consisting of a mixture of aggregate and liquid asphalt mixed in an approved type batch plant. Asphaltic concrete shall be placed and compacted on a prepared base course to the lines, grades, and compacted thickness called for on the plans or shown in the Bid Form.

The asphaltic wearing surface shall be N. C. Department of Transportation Asphaltic Concrete Mix Type I-2. The mix shall be prepared in a N. C. Department of Transportation approved plant and shall meet N. C. Department of Transportation Specifications Section 645 in every respect.

H. Placing: No asphaltic concrete shall be placed when temperature is less than 40° degrees F in the shade away from artificial heat.

The Contractor shall be equipped to place the mixture with approved spreading and finishing equipment, which shall spread the material to uniform density and strike a smooth finish true to cross-section and free from inequalities. Asphaltic concrete shall be placed in one course unless otherwise instructed by the Engineer.

While still hot, the mixture shall be rolled or tamped in places inaccessible to the rollers to give the required stability and density. Rolling shall be with 8- or 10-ton tandem rollers, weighing not less than 250 pounds per inch of width of roller tread. In rolling, care shall be taken not to damage structures of any type against which the mixture abuts.

Placing of the mixture shall be as nearly continuous as practicable; rollers shall not pass over unprotected end of the mixture except when laying of the course is discontinued for a length of time that will allow the mixture to become chilled, in which case the joint shall be cut back to expose an unsealed or granular surface for the full depth and width of the joint so a bond will be formed with the fresh mixture. When laying is resumed, the exposed edge of the joint shall be painted with a thin coat of hot asphalt cement or asphalt thinned with naphtha and the fresh mixture raked against the joint thoroughly tamped with hot tamps and rolled. At the beginning of each day's work, joints shall be formed as above described and at all other times when laying of the course is interrupted for a sufficient time to allow the material to chill. Longitudinal joints shall be formed in a similar manner as that described above when longitudinal joints are required.

Newly compacted surface shall be protected from traffic until it has become properly hardened by cooling.

9.16.9 Erosion Control and Grassing

A. General: The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of all Erosion

Control and Grassing construction as shown on drawings and as specified, in accordance with provisions of the contract documents and completely coordinated with that of all other trades.. 170

Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

B. Quality Standards: The Contractor shall utilize the best materials available and shall complete all work in accordance with Department of Transportation, Sedimentation and Pollution Control Act and these specifications.

C. Submittals: The Contractor shall submit data on the suppliers of all materials to be used in this project, germination results, seed content, etc.

D. Product Delivery, Storage, and Handling: Units shall be delivered and stored in a manner to provide full protection to all materials until ready to use.

E. Job Conditions: Verify suitability and condition of all areas to receive grassing.

F. Erosion Control - General: Contractor to take all precautions to avoid excessive siltation of nearby watercourses during the construction of this project. The erosion control used shall comply with the rules and regulations set forth in the latest edition of the North Carolina Administrative Code, Title 15, Chapter 4 "Sedimentation Control". Contractor to refer to notes on plans regarding erosion control. Temporary measures will be required as shown and described on the plans. Temporary measures shall remain in place until further possibility of stream siltation has passed at which time all temporary measures will be removed by the Contractor. Permanent measures will be required as shown and described on the plans. The Contractor shall be responsible for maintenance of the permanent measures until the completion of the project.

G. Methods and Measures: The following list of methods and measures for sediment controls should be considered and implemented by the Contractor:

1. Plan buffer zone erosion control measures in advance.
2. Install preliminary controls in advance of clearing and grubbing.
3. Prohibit pumping of ditches directly into any stream or lake. Provide settling basins.
4. Require excavated materials to be piled uphill from ditch - NOT on stream side of ditch.
5. Protect backfill material against accelerated erosion.
6. Tamp, seed and mulch within 30 days after disruption or final installation of materials.
7. Maintain buffer zone protection until area is stabilized.

H. Grassing - General: All unpaved areas disturbed by cause of construction under this project shall be seeded, fertilized and mulched under this contract. Preparation of seedbed and application of fertilizer, seed and mulch shall be performed in accordance with N. C. Board of Transportation Standard Specifications and the N.C Department of Environment and Natural Resources. Type of seed, fertilizer, lime and mulch shall be as called for on the plans for the season at the time of construction.

The above requirements shall be strictly adhered to as required by the Owners through the Engineers. The Contractor shall include his charge for all required grassing in the unit price proposed for erosion control. There will be no separate payment for grassing.

Please see Chapter 12, General and Special Conditions, Special Construction Technical Specifications for additional information and requirements for construction.

SECTION 33 13 00

DISINFECTION

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

Contractor shall furnish all labor, equipment, and material necessary to provide disinfection of an new water mains or existing water main that are altered during construction as shown on the drawings and described in the specifications.

Prior to being placed into operation the raw water main and production wells shall be disinfected in accordance with American Waterworks Association Standard C651-05 and North Carolina DENR standards. Two or more successive sets of samples, taken at 24-hour intervals, shall indicate microbiologically satisfactory water before the facility is placed in operation. Disinfection shall be accomplished by:

1. Fill utility with a 50 mg/L chlorine solution. Leave solution for 24 hours. After 24 hours, a residual of not less than 15 mg/L shall be maintained throughout the utility. If the residual drops below 15 mg/L, start the process over.

2. Thorough wetting of the surfaces to be disinfected by means of brush or spray application of a chlorine solution of concentration not less than two hundred parts per million (200 ppm) for a minimum contact time of two (2) hours.

1.2 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Shop Drawings

Disinfection Plan and Schedule

Dechlorination Plan

Product Data

Samples

Certificates

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 GENERAL

The Contractor shall disinfect all pipes, water mains that will come in contact with treated water and be used for human consumptions. A disinfection plan and schedule shall be developed and reviewed by the Engineer and shall be in accordance with all NCDENR – Regulations for disinfection of Potable Mains. Sampling shall be performed by a NCDENR Approved Laboratory.

3.2 DISPOSAL OF CHLORINATED WATER

The water used for disinfection shall be dechlorinated to a chlorine residual of 0.5 ppm or less prior to discharge. The Contractor shall prepare a plan for dechlorination prior to beginning operation.

--End of Section--

SECTION 33 30 00
SANITARY SEWERAGE

HARNETT REGIONAL WATER STANDARD SPECIFICATIONS FOR SANITARY SEWERAGE

CHAPTER 6

CONSTRUCTION OF SANITARY SEWER IMPROVEMENTS

REQUIREMENTS

Chapter 6
CONSTRUCTION OF SANITARY IMPROVEMENTS

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Chapter 6 CONSRUCTION OF SANITARY SEWER IMPROVEMENTS- REQUIREMENTS

Section 6.1 Construction of Sanitary Sewer Improvements

Contractors shall install all sanitary sewer improvements per the engineer's design as approved by HRW and permitted by the North Carolina Department of Environment and Natural Resources – Division of Water Quality (NCDENR-DWQ) unless the existing site conditions preclude such installation or significantly impact the project. Should site conditions warrant plan revisions then follow the procedures outlined in Section 4. 1. 11 above. All materials used in the sanitary sewer system improvements shall meet the requirements specified in the sections below unless otherwise approved by the HRW Engineering staff.

Once each project has been approved by the HRW and permitted by the state, the approved plans will be issued to the Contractor by the HRW. Copies of the approved plans will be stamped by the HRW Engineer as "Released For Construction," signed and dated to verify all plan changes requested by the state and the HRW have been addressed by the design engineer. During the pre-construction conference, the HRW Engineering staff will provide a copy of the state approved plans stamped as "Released For Construction" to the Contractor and the HRW Utility Construction Inspector. Only the state approved plans stamped by the HRW Engineer as "Released For Construction" shall be used for construction of any sanitary sewer system improvements. Preliminary plans or other plans not marked as "Released For Construction" by the HRW shall cause an immediate work stoppage until the approved plans marked as "Released For Construction" shall be issued and maintained on site by the Contractor.

Section 6.2 Construction Requirements for Sanitary Sewer Improvements

6.2.1 Material Submittals and Shop Drawings

All materials to be used in the extension of or connection to the existing Harnett Regional Water's sanitary sewer collection system must be approved by HRW before they are purchased and delivered on any project site. Submit six (6) copies of the following material specification sheets and all associated shop drawings for the material to be used in the in accordance proposed project shall be furnished to the HRW Engineer or the HRW Utility Construction Inspector to demonstrate compliance with the stipulated requirements as set forth herein these specifications under the "General Conditions." The contractor shall furnish all types of pipe and other incidentals required for the construction of a complete sanitary sewer system as shown on the drawings and as specified herein. Unless otherwise noted, the materials listed below are acceptable to the HRW for use in the construction of any extension of Harnett Regional Water's sanitary sewer collection system. Should the contractor desire to use materials not listed in these specifications, written permission must be obtained from both the Professional Engineer (P.E.) of record and the HRW Engineer or designated personnel as approved by the HRW Director.

All material shall be free from defects impairing strength and durability and be of the best commercial quality for the purposes specified. It shall have structural properties sufficient to safely sustain or withstand strains and stresses to which it is normally subjected and be true to detail. Connect to existing sanitary sewer mains and manholes as indicated by the project plans and under the direct supervision of the HRW Utility Construction Inspector or equivalent engineering representative of the HRW. Provide sanitary sewer main pipe, manholes, fittings, seals, combination air valves, air/vacuum valves, rubber seals, check valves, sanitary sewer service laterals, valve boxes, concrete valve box protective rings (donuts) and other system appurtenances as specified and where indicated per project utility plans approved by the HRW and permitted by the North Carolina Department of Environment and Natural Resources – Division of Water Quality (NCDENR- DWQ).

6.2.2 Material Approval

All material used in the construction of sanitary sewer improvements to Harnett Regional Water's existing sanitary sewer collection system must be approved by the HRW prior to purchase of the material. The HRW Engineer must receive the approved material submittals from the Engineer of Record by stamping one copy of the material submittal package and returning that stamped copy to the contractor and HRW. The contractor may then order the materials and have them delivered on site at the project location. Any materials that the HRW Utility Construction

Inspector finds on site that have not been approved by the HRW Engineer shall be removed immediately and construction shall be halted until the materials have been removed from the project site entirely. 71

Section 6.3 Materials For Construction of Sanitary Sewer Improvements

The Contractor shall use the materials specified by the Engineer in the project plans for the construction of any and all sanitary sewer improvement mains. The materials selected by the Engineer shall be utilized unless the material selected cannot be adapted to local conditions. In such cases the Professional Engineer (P.E.), the HRW Utility Construction Inspector and the HRW Engineer should be notified prior to the start of construction to request a change order for the material. The change order must be approved by the P.E. and the HRW Engineer before material changes shall be made by the contractor. Materials used in the construction of any and all sanitary sewer improvements shall conform to the following specifications:

6.3.1 Pipe

A. PVC Plastic Pipe (Standard Dimension Ratio) SDR 35 ASTM D3034

PVC Plastic Pipe (Standard Dimension Ratio) SDR 26 ASTM D3034

All pipe in this class shall conform to ASTM Standard D3034 for “Type PSM polyvinyl chloride (PVC) Sewer Pipe and Fittings.” The pipe shall be made of PVC plastic with integral wall bell and spigot joints for the conveyance of domestic sewer. The pipe shall be made of PVC plastic having a cell classification of 12454-B, 12454-C or 13364-B (with minimum tensile modulus of 3,450 MPa (500,000 psi) as defined in ASTM Standard D1784. The pipe fittings shall be made of PVC plastic having a cell classification of 12454-B, 12454-C or 13343-C as defined in ASTM Standard D1784. Compounds with superior properties are also acceptable.

1. Joints
Jointing system shall be elastomeric gasket type joints or push-on joints providing a watertight seal. Assembly of the joints shall be in accordance with the pipe manufacturer’s recommendations. The pipe manufacturer's instructions and recommendations for proper jointing operations shall be followed. All joint surfaces shall be lubricated with heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Each spigot end shall be suitably beveled to facilitate assembly.

2. Gaskets
Gaskets for the flanged joints shall conform to ASTM Standard C1330, Grade I rubber, full face type at least 1/8” thick. The mechanical joint gaskets shall be neoprene or other synthetic rubber. Natural rubber will not be acceptable for the gaskets.

3. Markings
Pipe in compliance with this standard shall be clearly marked at intervals of 5 feet as follows:

- Manufacturer’s name or trademark.
- Nominal pipe size.
- The PVC cell classification (for example 12454-B)
- The legend “Type PSM SDR 35” and the designation ASTM 3034

Fittings in compliance with this standard shall be clearly marked as follows:

- Manufacturer’s name or trademark.
- Nominal pipe size.
- The PVC cell classification (for example 12454-B)
- The legend “Type PSM SDR 35” and the designation ASTM 3034

4. Service Taps
All service taps shall be designed to be made on the PVC pipe using a Romac CB saddle or Fowler Inserta Tee hubbed with a schedule 40 or SDR 23.5 gasketed bell, rubber boot per ASTM Standard C443 and a stainless steel band. All taps must be designed to withstand low pressure air test required for the sewer main. Service taps installed with the newly constructed sewer mains shall be designed using an in-line wye fitting of the same material of the sanitary sewer main.

5. Service Pipe
All 4” and 6” sanitary sewer service laterals, service lines, cleanouts and associated fittings shall be Schedule 40 PVC conforming to ASTM Standards D2466 and D2672 respectively or SDR 23.5 conforming to ASTM Standard D2665 D3034 with glued or gasketed joints. The sanitary sewer service lateral shall include a long sweeping wye with a plug to cover the end of the cleanout until the final service line connection is completed by the plumber hired by the builder/owner.

6. Testing and Acceptance
Low pressure air tests will be performed on all newly laid sewer lines and associated service taps. The pressure holding time is based upon an average of 3 psi gage or a drop from 3.5 psi to 2.5 psi per the requirement of the ASTM Standard C828, latest revision. PVC pipe shall be capable of withstanding a two hour immersion test in a sealed container of 99.5 % Anhydrous Acetone and show no signs of flaking on interior or exterior when tested in accordance with ASTM Standard D2152. PVC pipe strength shall be capable of withstanding stiffness, flattening and impact test as scheduled or referenced in ASTM Standard D3034-73, SDR 35.

Tests shall be conducted to demonstrate joint performance at 5% maximum diametric deflection of the spigot as specified in ASTM Standard D3212. Maximum allowable pipe deflection shall be five (5%) percent of inside diameter. Deflection shall be checked by the contractor in the presence of the engineer and the HRW Utility Construction Inspector using a mandrel go/no-go device a minimum of 30 days following the installation. The mandrel device must be cylindrical in shape. The mandrel’s length and diameter (ID of proving ring) shall be sized for the sewer pipe installed on each project in accordance with Table 1 below. The mandrel shall be subject to the approval of the HRW Utility Construction Inspector and the Professional Engineer (P.E.).

Table 1

Nominal Diameter	Length	Diameter of Mandrel (Proving Ring)
6”	6”	5.65”
8”	8”	7.56”
10”	10”	9.45”
12”	10”	11.26”
15”	12”	13.78”

7. Leakage
All joints shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated by in the Harnett Regional Water’s General Conditions set forth per contract or within the one (1) year warranty period after approval shall be repaired by the contractor and at the expense of the contractor.

8. Infiltration
The contractor shall provide HRW a guarantee that infiltration shall not exceed 100 gallons per mile per day per inch diameter of pipe. The contractor shall provide the Professional Engineer (P.E.) a means to test infiltration after the completion of pipe installation prior to final acceptance.

B. Ductile Iron Pipe Centrifugally Cast for Water ANSI/AWWA C151/A21.51 Class 50 and ASTM A746, Standard Specification for Ductile Iron Gravity Sewer Pipe

All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer main shall be made because of the width and depth of trench where necessary to withstand extraordinary superimposed loading, special bedding, concrete cradle or special construction may be used. PVC plastic pipe DR 35 ASTM D3034 shall be used above 18 feet. Ductile iron ANSI A21.51 Class 50 shall be used below 18 feet. When transitioning from one pipe material to another, the pipe material must be consistent from one manhole to the next unless prior approval is given by the HRW.

All pipe in this class shall conform to either ANSI/AWWA C151/A21.51 Class 50 for "Ductile Iron Pipe, Centrifugally Cast for Water" or ASTM A746, Standard Specification for "Ductile Iron Gravity Sewer Pipe" or better. 73

1. Gaskets
Gaskets for the flanged joints shall conform to ASTM Standard C1330, Grade I rubber, full face type at least 1/8" thick. The mechanical joint gaskets shall be neoprene or other synthetic rubber. Natural rubber will not be acceptable for the gaskets.

2. Markings
Pipe in compliance with this standard shall be clearly marked at intervals of 5 feet as follows:

- Manufacturer's name or trademark.
- Nominal pipe size.
- NSF and UL approvals
- The legend "DI" and the designation ANSI C151

Fittings in compliance with this standard shall be clearly marked as follows:

- Manufacturer's name or trademark.
- Nominal pipe size.
- NSF and UL approvals
- The legend "DI" and the designation ANSI C151

3. Joints
The pipe shall have push-on joints, flanged joints or mechanical joints. The push on joints shall conform to ANSI/AWWA C110/A21.11, except the gaskets shall be neoprene or other synthetic rubber. Natural rubber will not be acceptable for the gaskets. Restrained push on joints shall be American "Lok-Fast" or "Lok-Ring"; U.S. Pipe "TR Flex" or Griffin "Snap-Lok" or "Field-Lok 350" gaskets. Flanged joints shall be ductile iron, flat faced to conform to ANSI/AWWA C115/A21.15, latest revision. Bolts shall be chamfered or rounded ends projecting ¼ to ½ inch beyond outer face of the nut to conform to ASTM Standard A307. Nuts shall conform to ASTM Standard A30, hexagonal per ANSI Standard B118.2.2, heavy semi-finished pattern.

4. Field Joints
Joints in buried locations shall be mechanical joint or push-on type unless otherwise indicated on the drawings. Bells on wall castings and wall sleeves shall be mechanical joint type with tapped holes for tie rods or stud bolts. All other joints shall be flanged unless otherwise indicated on the drawings. Grooved end couplings may be used in lieu of flanges provided rigid radius grooving is used to preclude pipe movement.
'

5. Mechanical Joints
Mechanical joints shall have grip rings and they shall be carefully assembled in accordance with the manufacturer's recommendations. "Megalug" fittings shall only be used for pipe sizes greater than 12 inches diameter. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Tie rods for mechanical joints shall conform to ASTM Standard A307. All bolts shall be uniformly tightened to the torque values listed in Appendix A of the ANSI/AWWA Standard C111/A21.11. Over tightening of bolts to compensate for poor installation practice will not be permitted. The holes in mechanical joints with tie rods shall be carefully aligned to permit installation of the tie rods. In flange and mechanical joint pieces, holes in the mechanical joint bells and the flanges shall straddle the top (or side for

vertical piping) centerline. The top (or side) centerline shall be marked on each flange and mechanical joint piece at the foundry. 74

6. Push-On Joints
The pipe manufacturer's instructions and recommendations for proper jointing operations shall be followed. All joint surfaces shall be lubricated with heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Each spigot end shall be suitably beveled to facilitate assembly.

7. Flanged Joints
Pipe shall extend completely through screwed-on flanges. The pipe end and flange face shall be finish machined in a single operation. Flange faces shall be flat and perpendicular to the pipe centerline. When bolting flanged joints, care shall be taken to avoid restraint on the opposite end of the pipe or fitting which would prevent uniform gasket compression or which would cause unnecessary stress in the flanges. One flange shall be free to move in any direction while the flange bolts are being tightened. Bolts shall be tightened gradually and at a uniform rate, so that gasket compression is uniform. Special care shall be taken when connecting to pumping equipment to ensure that pipe stresses are not transmitted to the pump flanges. All such piping shall be permanently supported so that accurate matching of bolt holes and uniform contact over the entire surface of abutting pump and piping flanges are obtained before installation of any bolts in those flanges. In addition, pump connection piping shall be free to move parallel to its longitudinal centerline while the bolts are being tightened.

8. Flanged Coupling Adapters
Flanged coupling adapters shall be installed in strict accordance with the coupling manufacturer's recommendations. After the pipe is in place and bolted tight, the proper location of holes for the anchor studs shall be determined and the pipe field drilled. Anchor stud holes shall be drilled completely through the pipe wall. The hole diameter shall be not more than 1/8 inch larger than the diameter of the stud projection.

9. Mechanical Couplings
Mechanical couplings shall be carefully installed in accordance with the manufacturer's recommendations. A space of at least 1/4 inch and not more than one inch shall be left between the pipe ends. Pipe and coupling surfaces which contact gaskets shall be clean and free from dirt and other foreign matter during assembly. All assembly bolts shall be uniformly tightened so that the coupling is free from leaks and all parts of the coupling are square and symmetrical with the pipe. Following installation of the coupling, damaged areas of shop coatings on the pipe and coupling shall be repaired to the satisfaction of the Engineer.

10. Wall Castings
Unless otherwise indicated on the drawings, wall castings shall be provided where cast iron pipes pass through concrete walls. Where a flange and mechanical joint piece is to connect to a mechanical joint wall casting, the bolt holes in the bell of the wall casting shall straddle the top (or side for vertical piping) centerline of the casting and shall align with the bolt holes in the flange and mechanical joint piece. The top centerline shall be marked on the wall casting at the foundry. Wall castings shall have mechanical joints with water stop and tapped holes; single casting or fabricated ductile iron shall be “Adjustable Wall Pipe” as manufactured by Midwest Pipe Fabricators, Omaha, Nebraska or approved equal. All holes shall be sized according to project plans and provided with removable plugs.

11. Reducers
Reducers adjacent to flow meters and pumps shall be eccentric pattern. Eccentric reducers shall be installed with the straight side on top so that air traps are not formed. Unless otherwise indicated on the drawings, all other reducers shall be concentric pattern.

12. Outlets
Where a 12” or smaller branch outlet is indicated and the diameter of the line pipe is at least twice the diameter of the branch, either a tee, factory welded-on boss, or a tapping saddle will be acceptable. Gauge

connections in the cast iron piping shall conform to the requirements of the pressure gauge manufacturer's recommendations and this section. 75

Connection of gauges to cast iron-pipe six (6") inches and smaller shall be made using a tapping saddle or a tee complete with a blind flange drilled and tapped to accept the gauge piping specified. Connection to gauges to 8 inch and larger piping shall be made by means of a factory welded-on boss or a tapping saddle. Drilling and tapping of the pipe wall will also be acceptable provided the wall thickness, minus the foundry tolerance, at the point of connection equals or exceeds the wall thickness required for a full 4-thread engagement in accordance with Table A.1, Appendix A of ANSI/AWWA Standard C151/A21.51.

13. Shop Coating and Lining
The interior of all pipe and fittings for water service shall be coated with Protecto 401 or approved equal for protection against attach by sewer gases such as methane and hydrogen sulfide. The exterior surfaces of all pipe and fittings which will be exposed to interior locations shall be shop primed and then painted after installation. Flange faces shall be coated with rust-preventive compound. Exterior surfaces of all other pipe and fittings shall be asphaltic coated.

14. Handling
Pipe, fittings, and accessories shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage the pipe and fittings. Hooks inserted in ends of pipe shall have broad, well-padded contact surfaces. Pipe and fittings in which the lining has been damaged shall be replaced. With the concurrence of the Engineer, small and readily accessible damaged areas may be repaired. All pipe coating which has been damaged shall be repaired by the contractor before the pipe is installed.

15. Cutting Pipe
Cutting shall be done in a neat manner, without damage to the pipe or the lining. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the end of the pipe shall be dressed with a file or power grinder to remove all roughness and sharp edges. The cut ends of push-on joint pipe shall be suitable beveled. Ends of ductile iron pipe shall be cut with a portable guillotine saw, abrasive wheel, saw, milling cutter, or oxyacetylene torch. The use of hydraulic squeeze type cutters will not be permitted. Field-cut holes for saddles shall be cut with mechanical cutters; oxyacetylene cutting will not be permitted.

16. Cleaning
The interior of all pipe and fittings shall be thoroughly cleaned of all foreign matter prior to installation and shall be kept clean until the work has been accepted. Before joining pipe sections, all joint contact surfaces shall be wire brushed if necessary, wiped clean, and kept clean until jointing is completed. Precautions shall be taken to prevent foreign material from entering the pipe during installation. Debris, tools, clothing, or other materials shall not be placed in or allowed to enter the pipe. Whenever pipe laying is stopped, the open end of the pipe shall be sealed with a watertight plug which will prevent trench water from entering the pipe.

17. Inspection
Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation; spigot ends shall be examined with particular care. All defective pipe and fittings shall be removed from the site of the work.

18. Alignment
Piping shall be laid to the lines and grades indicated on the drawings. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the values stipulated in Table 5 or Table 6 of the AWWA Standard C600, unless specially designed bells and spigots are provided. Either shorter pipe sections or fittings shall be installed where required to conform to the alignment or grade indicated on the drawings. 76

19. Laying Pipe

Pipe shall be protected from lateral displacement by placing the specified pipe embedment material. Under no circumstances shall pipe be laid in water, and no pipe shall be laid under unsuitable weather or trench conditions. Pipe shall be laid with the bell ends facing the direction of laying except when reverse laying is specifically authorized by the Engineer.

20. Connections with Existing Piping:
Connections between new work and existing piping shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by the HRW. The customers shall be provided at least 48 hours' notice for any planned service outages by placing a door hanger notice on each door of the customers‟ dwellings before the existing lines may be shut off or removed from service. Facilities shall be provided for proper dewatering and disposal of all water removed from dewatered lines and excavations without damage to adjacent property. Special care shall be taken to prevent contamination when dewatering, cutting into, and making connections with existing potable water piping. Trench water, mud, or other contaminating substances shall not be permitted to enter the lines. The interior of all pipe, fittings and valves installed in such connections shall be thoroughly cleaned and then swabbed with, or dipped in, chlorine solution having a chlorine content of 200 milligrams per liter (mg/l).

21. Concrete Encasement
Concrete encasement shall be installed as indicated on the drawings. Concrete and reinforcing steel shall be as specified in the cast-in-place concrete section. All pipe to be encased shall be suitably supported and blocked in proper position, and shall be anchored to prevent flotation.

22. Reaction Anchorage and Blocking
All exposed piping with mechanical couplings, push-on or mechanical joints, or similar joints subject to internal pressure shall be blocked, anchored, or harnessed to preclude separation of joints. All push-on and mechanical joint tees, wye (Y) fittings, bends deflecting 22.5° degrees or more, and plugs which are installed in buried piping (subjected to internal hydrostatic heads in excess of 30 feet) shall be provided with suitable reaction blocking, anchors, joint harness, or other acceptable means for preventing movement of the pipe caused by internal pressure

Concrete blocking shall extend from the fitting to solid undisturbed earth and shall be installed so that all joints are accessible for repair. The dimensions of concrete reaction blocking shall be as indicated on the drawings or as directed by the Engineer. If adequate support against undisturbed ground cannot be obtained, metal harness anchorages shall be installed to provide the necessary support. Metal harness anchorages shall consist of steel rods extending across the joint and securely anchored to pipe and fitting, or other adequate anchorage facilities shall be installed to provide the necessary support. If the lack of suitable solid vertical excavation face is due to improper trench excavation, metal harness anchorages shall be furnished and installed by the contractor and at the expense of the contractor. Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, above grade, or exposed within structures, shall be provided as required by the drawings or as directed by the Engineer.

All steel clamps, rods, bolts, and other metal accessories used in tapping saddles, reaction anchorages, or joint harness subject to submergence or contact with earth or other fill material and not encased in concrete shall be protected from corrosion by two coats of thixotropic coal tar applied in the field to clean dry metal surfaces. The first coat shall be dry and hard before the second coat is applied. Metal surfaces exposed above grade or within structures shall be painted in accordance with the painting section.

23. Service Taps
All service taps made on the existing sewer mains constructed with ductile pipe shall be made with a Romac CB saddle or Fowler Inserta Tee hubbed with a schedule 40 or SDR 23.5 Gasketed bell, rubber boot per ASTM Standard C443 and a stainless steel band. All taps must be able to withstand low pressure air test required for the sewer main. Service taps installed with the newly constructed sewer mains shall be installed using a wye fitting of the same material of the sewer main.

24. Service Pipe

All 4” and 6” sanitary sewer service laterals, service lines, cleanouts and associated fittings shall be Schedule 40 PVC conforming to ASTM Standards D2665 and D2466 respectively and/or SDFR 23.5 conforming to ASTM Standard D3034 with glued or gasketed joints.

25. Testing and Acceptance
Low pressure air tests will be performed on all newly laid sewer lines and associated service taps. The pressure holding time is based upon an average of 3 psi gage or a drop from 3.5 psi to 2.5 psi per the requirement of the ASTM Standard C828, latest revision. Maximum allowable pipe deflection shall be five (5%) percent of inside diameter. Tests to demonstrate deflection of rigid pipe by using a mandrel go/no-go device are not required by the HRW.

26. Leakage
All joints shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated by in the Harnett Regional Water’s General Conditions set forth per contract or within the one (1) year warranty period after approval shall be repaired by the contractor and at the expense of the contractor.

27. Infiltration
The contractor shall provide HRW a guarantee that infiltration shall not exceed 100 gallons per mile per day per inch diameter of pipe. The contractor shall provide the Professional Engineer (P.E.) a means to test infiltration after the completion of pipe installation prior to final acceptance.

28. Dimensions
The thickness class for cast iron pipe shall be as indicated in the following table:

Location	Nominal Size (Inches)	Pressure Class (psi)
All push-on	3 through 12	350
All flanged	3 through 12	350

29. Drawings and Data
Complete layout drawings, details and specifications covering all cast iron piping and accessories shall be submitted to the HRW during the plan approval and the pre-construction conference as outlined in these specifications.

C. Semi-Rigid PVC Truss Pipe for Gravity Sewer ASTM D2680

All semi-rigid PVC truss pipe in this class shall be manufactured by extruding Class 12454 PVC resin per ASTM Standard D1784 into a truss shape forming an inner and outer wall supported by webs. After extrusion the voids between the trusses shall be filled with an air entrained Portland cement perlite filler or other inert filler material exhibiting the same degree of performance. The pipe shall exhibit minimum pipe stiffness of 200 psi when tested in accordance with ASTM Standard D2412 and shall be furnished in laying lengths of 12 feet 6 inches. The pipe shall meet or exceed ASTM Standard D2680 or latest revision.

The pipe fittings shall conform to ASTM Standard D2680, latest revision. The pipe joints shall be supplied with elastomeric (Gasketed) seals that meet the requirements of ASTM F477, latest revision and when these joints are assembled they shall conform to the test of ASTM 3212 showing no leakage.

1. Installation
For pipe installed to depths of 15 feet or less, semi-rigid Gasketed PVC truss pipe shall be installed per the manufacturer‟s recommendations and shall meet the ASTM Standard D2640, Appendix XI. Backfill material used to a point one (1) foot above the barrel of the pipe shall be select materials that are free of large stones and clods larger than 1-1/2 inches in diameter. Class I, II, III or IV materials per ASTM 2680, 78

Appendix XI are suitable for bedding, haunching and initial backfill. The haunching and initial backfilling for Class II, III or IV soils shall be placed completely under pipe haunches and up each side in uniform layers not exceeding 6 inches in depth with each layer carefully and uniformly compressed or compacted. Where sub grade is unstable or water is present in quantities sufficient to make uniform bedding of the pipe impossible, the contractor will be required by the engineer to stabilize the trench bottom with stabilization stone, 4 inches minimum, or as directed by the HRW Engineer or the HRW Utility Construction Inspector. All trench stabilization stone shall be placed in the trench carefully to avoid damage to previously installed sections of pipe.

For pipe installed to depths greater than 15 feet, the contractor shall bed the pipe with granular stone (Class I) bedding no less than 6 inches thick below the pipe barrel and up to the spring line of the pipe to the full width of the trench. All bedding stone at these depths shall be included with the pipe price submitted per linear foot of pipe installed.

2. Service Taps
All service taps shall be designed to be made on the PVC pipe using a Romac CB saddle or Fowler Inserta Tee hubbed with a schedule 40 or SDR 23.5 gasketed bell, rubber boot per ASTM Standard C443 and a stainless steel band. All taps must be designed to withstand low pressure air test required for the sewer main. Service taps installed with the newly constructed sewer mains shall be designed using an in-line wye fitting of the same material of the sanitary sewer main.

3. Service Pipe
All 4” and 6” sanitary sewer service laterals, service lines, cleanouts and associated fittings shall be Schedule 40 PVC conforming to ASTM Standards D2466 and D2672 respectively or SDR 23.5 conforming to ASTM Standard D2665 D3034 with glued or gasketed joints. The sanitary sewer service lateral shall include a long sweeping wye with a plug to cover the end of the cleanout until the final service line connection is completed by the plumber hired by the builder/owner.

4. Testing and Acceptance
Low pressure air tests will be performed on all newly laid sewer lines and associated service taps. The pressure holding time is based upon an average of 3 psi gage or a drop from 3.5 psi to 2.5 psi per the requirement of the ASTM Standard C828, latest revision. PVC pipe shall be capable of withstanding a two hour immersion test in a sealed container of 99.5 % Anhydrous Acetone and show no signs of flaking on interior or exterior when tested in accordance with ASTM Standard D2152. PVC pipe strength shall be capable of withstanding stiffness, flattening and impact test as scheduled or referenced in ASTM Standard D3034-73, SDR 35.

Tests shall be conducted to demonstrate joint performance at 5% maximum diametric deflection of the spigot as specified in ASTM Standard D3212. Maximum allowable pipe deflection shall be five (5%) percent of inside diameter. Deflection shall be checked by the contractor in the presence of the engineer and the HRW Utility Construction Inspector using a mandrel go/no-go device a minimum of 30 days following the installation. Deflection tests will not be required for semi-rigid pipe with a pipe stiffness of 150 psi or greater per ASTM Standard D2412.

5. Leakage
All joints shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated by in the Harnett Regional Water’s General Conditions set forth per contract or within the one (1) year warranty period after approval shall be repaired by the contractor and at the expense of the contractor.

6. Infiltration
The contractor shall provide HRW a guarantee that infiltration shall not exceed 100 gallons per mile per day per inch diameter of pipe. The contractor shall provide the Professional Engineer (P.E.) a means to test infiltration after the completion of pipe installation prior to final acceptance. 79

D. Reinforced Concrete Pipe (RCP) for Gravity Sewer ASTM D2680

This specification covers reinforced concrete pipe (RCP) intended to be used for the conveyance of sewage, industrial wastes, and storm water, and for the construction of culverts. Pipe manufactured in accordance with this specification shall be of five classes identified as Class I, Class II, Class III, Class IV, and Class V. Pipes shall conform to the ASTM Standard C76 Class III, Class IV, and Class V of the design and strength requirements for diameter, wall thickness, and compressive strength as shown on the drawings. The approval and acceptability of the pipe shall be determined by the results of testing concrete batch samples, cores and cylinders using the three-edge bearing test, absorption test, material test, visual inspection, crushing test, and compression test methods.

The pipe interior shall be smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. The concrete mass shall be dense and uniform. The pipe manufacturing process shall be of the "wet cast" type or of the "dry cast" type using the BiDi manufacturing process or the counter-rotating packer head manufacturing process or the internal care and external jacket process. "Wet cast" forms shall not be removed for at least 8 hours after concrete placement or until the concrete strength has reached 2,000 psi, whichever comes first. For the BiDi and counter-rotating packer head process, plastic or fiberglass form rings shall be placed on the spigot end of the pipe immediately after removal of the forms and shall not be removed prior to the initial set of the concrete. Pipe shall be steam cured after forming. Pipe forms and equipment shall be maintained in excellent condition and shall be kept clean and free of any condition which may contribute to lower quality pipe.

Cement shall be non-air-entraining Portland cement conforming to ASTM C150, Type II. The use of any admixture shall be subject to the specific approval of the HRW Utility Construction Inspector and the Engineer. The aggregate shall be so sized, proportioned, graded, and mixed with such proportions of Portland cement, blended hydraulic cement, or Portland cement and supplementary cementing materials, or admixtures, if used, or a combination thereof, and water to produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of the ASTM Standard C76 and these specifications. Fine aggregate shall consist of washed inert natural and conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of 8 percent when subjected to 5 cycles of the soundness test using magnesium sulfate. Coarse aggregate shall consist of well-graded crushed dolimitic or calcitic limestone otherwise conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of 8 percent when subjected to 5 cycles of the soundness test using magnesium sulfate. The minimum alkalinity of the finished concrete shall be 50 percent as a calcium carbonate equivalent. Documentation that the aggregates to be used in the manufacture of reinforced concrete pipe meet these requirements shall be submitted to the HRW Utility Construction Inspector and the Engineer.

Pipe reinforcement methods considered in this specification are circumferential reinforcement, longitudinal reinforcement, and joint reinforcement. Pipe shall be subjected to either steam curing, water curing, or the two methods combined, provided that the required compressive strength is attained as prescribed herein these specifications. The 28-day compressive strength of the concrete, as indicated by cores cut from the pipe and cylinder testing shall not be less than the design compressive strength for each RCP size and class. The concrete mass shall be dense and uniform. Reinforcement shall be circular for all concrete pipe(s). Quadrant steel shall not be used.

Pipe reinforcement shall be as specified in the ASTM Standard C76 with the following exceptions:
The maximum variation in the radial position of the reinforcement in the pipe wall shall be + ¼” inch for the outer layer and + ½” inch and ¼” for the inner layer. Reinforcement shall be secured by steel spacers that tie the inner cage to the outer cage and brace to the outside form only. Spacers shall be located circumferentially around the pipe at not less than 90 degrees radial spacing and axially along the pipe at not less than 24-inch spacing. Reinforcement shall be installed in both the bell and the spigot. . At least three circumferential reinforcement wires shall be in the bell area, and longitudinal reinforcement shall extend to the end of the bell and shall be continuous with the wires in the barrel. At least two circumferential reinforcement wires shall be in the spigot area, and longitudinal reinforcement shall extend to within 1” inch of the end of the spigot.

Only one layer of steel mesh shall be allowed for each cage. The minimum steel area specified by ASTM C76 for each cage shall be met with one layer of steel reinforcement.

Pipe may be rejected for any of the following reasons:

- Exposure of any steel reinforcement in any surface of the pipe, except for ends of longitudinal reinforcing in the bell ends of reinforcement spacers.
- Any shattering or flaking at a crack.

- Voids exceeding ¼” inch in depth, with the exception of a few minor bug holes, on the interior and exterior surfaces of the pipe.
- Unauthorized pipe repair or application of any wash coat of cement or grout.
- A deficiency greater than ¼” inch from the specified wall thickness of pipe 30 inches or smaller in internal diameter.
- A deficiency greater than 6% percent from the specified wall thickness of pipe larger than inches in internal diameter, except that the deficiency may be 8 percent adjacent to the longitudinal form joint, provided that the additional deficiency does not lie closer than 20 percent of the internal diameter of the pipe. The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe.
- A variation from the specified internal diameter in excess of 3 percent or interior surfaces which have been reworked after placing of concrete. The variation in internal diameter permitted herein does not apply to gasket contact surface in gasketed joint pipe.
- A hollow spot (identified by tapping the internal surface of the pipe) which is greater in any dimension than the specified wall thickness. Repair of such defective areas not exceeding these limitations may be made as specified herein.
- Defects that indicate imperfect molding of concrete or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than area equal to a square with a side dimension equal to the wall thickness or deeper than two times the maximum graded aggregate size, or local deficiency of cement resulting in loosely bonded concrete, the area of which exceeds in size limits of area described above when the defective concrete is removed. Repair of such defects not exceeding these limits may be made as specified herein.

  Any of the following:
    - A crack having a width of 0.01 throughout a continuous length of 36 inches or more.
    - A crack having a width of 0.01 inch to 0.03 inch or more throughout a continuous length of 1 feet or more.
    - Any crack showing two visible lines of separation for a continuous length of 2 feet or more or an interrupted length of 3 feet or more anywhere in evidence, both inside and outside.
    - Cracks anywhere greater than 0.03 inches in width.

The pipe shall be clearly marked as required by ASTM C76 in a manner acceptable to the HRW Utility Construction Inspector and the Engineer. The markings may be at either end of the pipe for the convenience of the manufacturer, but for any one size shall always be at the same end of each pipe length. Pipe shall not be shipped until the compressive strength of the concrete has attained full strength for each RCP size and class and not before 5 days after manufacture and/or repair, whichever is the longer.

Pipe shall have a minimum laying length of 12 feet, except for closure at structures. Shorter lengths of pipe for closure of structures shall be obtained by saw-cutting full lengths of pipe. The length of the incoming and outgoing concrete pipe at each structure shall be at least 4 feet beyond the outside face of the structure wall. Each length of pipe shall be checked against the length noted on the shop drawings. Pipe more than 1-1/2” longer than that shown on the shop drawings shall not be used. Variations in length 81
of the same pipe shall not exceed ASTM C76 requirements.

During manufacturing measuring devices shall be used to assure joint assembly is within the tolerance of ASTM C76 and these specifications. The Engineer shall have the right to take samples of the concrete after it has been mixed or as it is being placed in the forms or molds and to make inspection and tests thereof.
At the time of inspection, the pipe will be carefully examined for compliance with the specifications and the approved shop drawings. All pipes shall be inspected for general appearance, dimension, blisters, cracks, roughness, soundness, etc. The surface shall be dense, smooth, and close-textured. Cores also shall serve as a basis for rejection of pipe if lamination or poor bond of reinforcement is apparent.

Unsatisfactory or damaged pipe will be either permanently rejected or returned for minor repairs. Only that pipe actually conforming to the specifications and accepted will be listed for approval, shipment and payment. Approved pipe will be so stamped or stenciled on the inside before it is shipped. All pipe which has been damaged after delivery will be rejected, and, if such pipe already has been laid in the trench, it shall be acceptably repaired, if permitted, or removed and replaced at the discretion of the HRW Utility Construction Inspector.

Pits, blisters, rough spots, breakage and other imperfections may be repaired, subject to the approval of the Engineer and the HRW Utility Construction Inspector, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Non-shrink cement mortar shall be used for repairs and shall have a minimum compressive strength of 6,000 psi at 7 days and 7,000 psi at 28 days when tested in 3-inch cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the approval of the Engineer.
The first 6 inches of the bell and spigot ends of each piece of pipe shall be painted at the place of pipe manufacturing with a latex paint to be approved by the Engineer and the HRW Utility Construction Inspector. Coordinate type of paint (or alternative coating) with the joint testing apparatus manufacturer as specified.

At the start of the pipe manufacture, a set of three test cylinders shall be taken, cured, and tested. One core shall be taken and tested from each of the first ten pieces of pipe produced. No additional pipe shall be manufactured until the Engineer has inspected the cores, the cylinders and cores have been tested, and the Engineer has reviewed the results of the core and cylinder testing. A relationship shall be established between the compressive strength of test cylinders stored in a standard manner compared to cores taken from the corresponding finished pipe. All cylinders, coring, and testing shall be by the pipe manufacturer. The results shall be furnished immediately to the Engineer and to the HRW Utility Construction Inspector upon request. If a satisfactory relationship between core and cylinder test strengths is demonstrated as specified herein, further core testing may be waived by the Engineer and the HRW Utility Construction Inspector except as specified herein. Should this relationship not be established, one core shall continue to be taken and tested from each piece of pipe until the manufacturer's quality control has been improved to the extent that a satisfactory relationship between core and cylinder test strengths is demonstrated between the compressive strength of test cylinders stored in a standard manner compared to cores taken from the corresponding finished pipe.

The Engineer and the HRW Utility Construction Inspector shall each have the right to direct that test cores be taken from pieces of the finished pipe as he selects for inspection and for such tests as he may wish to apply. Holes left by the removal of cores shall be filled with non-shrink grout by the manufacturer as approved by the Engineer and the HRW Utility Construction Inspector. Core drilling, testing, and filling shall be carried out by the pipe manufacturer as a subsidiary requirement of the manufacturer. A 9-inch x 9-inch waterproofing self-adhering membrane (Gator Wrap, Mac Wrap or equal) shall be placed over the core holes on the exterior of the pipes. The number of cores shall not exceed the requirements of ASTM C76. 82

One test core shall be taken for every 500 linear feet of pipe manufactured but not less than once each day on which pipe is manufactured for the project. Cores may be reduced to one set of two per week but not less than one set for every 1,500 linear feet, if a continued satisfactory relationship is established between cores and cylinders made and cured in the standard manner. This relationship shall not vary by more than 10 percent more or less from the average ratio. Cores may be drilled in any manner which will provide a smooth core face. All pipe cylinders and cores shall be 4-inches in diameter. Cores shall be carefully saw-trimmed and capped in a vertical position with a sulfur cap of minimum thickness at least one day before being tested.

Cylinder and core testing shall conform to Standard ASTM Methods and may be performed by the manufacturer at his test facilities if approved by the Engineer. Otherwise, the manufacturer shall employ an independent testing laboratory for cylinder and core testing at no additional cost to the HRW. All other ASTM Standards, including but, not limited to the following, shall apply to elements and components of RCP as follows:

A36/A36M Specification for Carbon Structural Steel
A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement
A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement
A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement **A706/A706M** Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement **C33** Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Standard]
C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Metric]
C150 Specification for Portland Cement
C260 Specification for Air-Entraining Admixtures for Concrete
C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile
C595 Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
C822 Terminology Relating to Concrete Pipe and Related Products
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1116 Specification for Fiber-Reinforced Concrete and Shotcrete

1. Joints for Concrete Pipe
Joints for concrete pipe shall be the bell and spigot type joint conforming to ASTM C443/C361 and the Bureau of Reclamation Type R -4 except as modified by these specifications with provisions for using a round rubber o-ring gasket in a recess in the spigot end of the pipe. The bevel on the bell of the pipe shall be between 1 ½ degrees and 2 degrees. The diameters of the joint surfaces which compress the gasket shall not vary from the true diameters by more than 1/16th of an inch. Longitudinal reinforcement shall be continuous from end of spigot to end of bell and shall be expanded within the bell.

The round rubber o-ring gaskets shall conform to ASTM C443 except as otherwise specified herein. Gaskets shall be furnished by the supplier. The gasket manufacturer shall have the following tests performed by a qualified independent testing laboratory on the gaskets proposed for this project. Specimens of the gaskets shall be heated in a dry oven to 150 degrees F for 6-hours duration, and five specimens shall be tested by immersion, one each as follows: 72-hour immersion in saturated hydrogen sulfide solution, 72-hour immersion in 1 percent NaOH solution, 72-hour immersion in standard soap solution (80 percent alcohol), 72-hour immersion in 10 percent NaCl solution. Specimens of the gaskets shall be subjected to tensile tests of approximately 100 psi before and after immersion and heating tests and shall show an elongation of at least 25 percent. Upon release from the tensile tests, each specimen shall return to its original length. The specimens shall show no detrimental change in color, texture, or feeling upon completion of the above tests. The manufacturer shall supply test data and affidavits showing compliance with these requirements. Tests shall have been conducted within six months of the start of manufacture of the pipe.

The pipe and pipe joints shall be designed and manufactured so that the pipe and joints will withstand an external water pressure of 15 psi without leakage through the pipe wall or by the gasket. The pipe manufacturer shall provide facilities and factory test all pipe used in the Contract Work. Such tests shall be made by an internal vacuum as specified below. The Engineer and the HRW Utility Construction Inspector shall be notified for witnessing all tests.

Install sealed end caps/plugs fabricated with the specified joints and gaskets identical to those of the pipe. Connect a vacuum source with shut-off valve and vacuum gage.
Draw a vacuum of 7 inches of mercury (Hg) then shut off valve and disconnect vacuum source. Measure the length of time required for the vacuum to decrease from 7 to 5 inches of mercury (Hg). Times shall not be less than the following:

Minimum Time for 2 inches of mercury (Hg) pressure
decrease or drop in the pipe between manholes

Pipe Diameter (inches)	8 ft. pipe (min-sec)	12 ft. pipe (min-sec)
24	0:50	1:15
27	1:03	1:35
30	1:18	1:57
36	1:52	2:49

42	2:33	3:50
48	3:20	5:00
54	4:13	6:20
60	5:13	7:49

If the vacuum test fails, determine if the failure was a joint failure, or wall porosity failure. Mark the pipe and remove it to eliminate any possibility that the pipe will be shipped to the project site for any Contract Work. Correct product quality control to conform to all test requirements and standards. All pipe furnished shall be so tested and shall meet the test requirements. The pipe and ends of the pipe shall be made true to form and dimension. The manufacturer shall inspect and measure all pipe ends for out-of-roundness and square and shall mark his certification on the interior of the pipe. The manufacturer shall furnish the Engineer and the HRW Utility Construction Inspector upon request affidavits showing the results of these measurements and stating pipe meets the requirements of ASTM C76 and ASTM C443/C361 and these specifications.

2. RCP/DIP Adaptors: Ductile iron pipe (DIP) shall conform to these specifications for DIP and reinforced concrete pipe (RCP) shall conform to these specifications for RCP for gravity sewer pipe. Where concrete collars are to be poured around the DIP, the pipe shall be cleaned to bear metal by grinding, wire brushing or sandblasting. One-half (1/2") inch round studs are to be welded to the DIP at quarter points of pipe in center segment with wire one (1") inch minimum cover. DIP shall then be coated with concressive liquid Bonding Agent and allowed to cure in accordance with the ASTM Technical Bulletin.

WWF shall be shaped to proper Radius and lap welded. WWF shall be sized and shape to conform to ASTM specifications for the appropriate size and class of concrete pipe. WWF shall be held in place with WWF spacers not more than 18" apart circumferentially. Concrete shall be a minimum of 5000 psi.

3. Pipe Installation: Care shall be taken in loading, transporting, and unloading to prevent damage to the pipe. Pipe shall not be dropped. All pipe shall be examined by the Contractor before laying, and installation. The Engineer and the HRW Utility Construction Inspector shall be notified of any defect. No piece shall be installed which is defective in any way unless authorized in writing by the Engineer and the HRW Engineer.

Any pipe damaged during transport or unloading at the site or during construction operations shall be immediately set aside and stored by the Contractor for inspection by the Engineer and the HRW Utility Construction Inspector. Any pipe damaged during manufacturing or shipping operations shall be immediately set aside and stored by the manufacturer for inspection by the Engineer and the HRW Utility Construction Inspector. If any damaged pipe is approved for repair, the pipe shall be repaired with epoxy mortar by the manufacturer and re-inspected by the Engineer and the HRW Utility Construction Inspector. If not approved for repair, the pipe shall be removed from the site and replaced by the manufacturer.
Excavation, bedding and backfill and other earthwork requirements shall be as specified in Chapter 6 construction of Sanitary Sewer Improvements. As soon as the excavation is completed as shown on the drawings and confirmed by a laser to the required sub grade elevation, the Contractor shall compact the sub grade, remove excess earth from the trench by hand, and place, grade, and compact the stone bedding material in the trench to a depth called for in these specifications. There shall be no water observable in the trench bottom or bedding. Should water be present, all pipe installation shall immediately cease until dewatering of the site is improved to the extent that no water is present in the trench or the bedding material.

A depression shall be formed with hand tools in the compacted bedding material along the pipe to final bedding elevation and shall be contoured to match the curvature of the pipe for continuous support of at least the bottom 30 degrees of the pipe. The depression shall be slightly deeper at the joint to prevent bedding material from entering the bell and interfering with seating the spigot of the next pipe section and to provide space for installing the membrane collar and the grade checked by laser and adjusted as necessary, always providing full support of the bottom 30 degrees of the pipe. Blocking under the pipe will not be permitted. Before the pipe is lowered into the trench, the spigot and bell shall be clean and free from dirt. Gasket and bell shall be lubricated by a vegetable lubricant which is soluble in water and harmless to the rubber gasket. The pipe shall be properly aligned in the trench to avoid any possibility of contact with earth or bedding and fouling the bell, spigot, or gasket. As soon as the spigot is centered in the bell of the previously laid pipe, it shall be forced home by an approved method. The preferred driving method shall be as follows: Pipe sections are driven home by using a section of pipe or other ramming device that will apply even pressure to a round section of forgiving material such as hard rubber or wood that covers the entire circumference of the spigot end of the pipe to avert damaging the ends of the pipe during installation. The maximum gap on the inside of the pipe shall be 0.05 foot. The maximum gap on the outside of the pipe shall be 0.10 foot.

As soon as the pipe is in place and its correct position is confirmed and bedding material is in place and compacted as indicated on the drawings for at least one-half the length of pipe. Each joint between every manhole section, catch basin or pipe joint shall be sealed with an external rubber sleeve (similar to Mac-Wrap, Infi-Shield Gator Wrap as manufactured by Sealing Systems, Inc) or approved equal.

The assembled joint shall be tested in accordance with ASTM C 1103 with a joint tester to verify the joint seal. If test indicates a improper seal, the pipe shall be removed, cleaned, remade, and retested until a good seal is achieved between pipe sections. Bedding material shall then be place and compacted to the required depth as shown on the drawings and the pipe backfilled in compacted layers of common fill as shown on the drawings, details and these specifications. The Contractor shall protect the installed pipe against the inflow of surface water against floatation until the work is completed, inspected and accepted by the HRW.

4. Leakage
All joints shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated by in the Harnett Regional Water's General Conditions set forth per contract or within the one (1) year warranty period after approval shall be repaired by the contractor and at the expense of the contractor

6.3.2 Manhole Material

Manholes shall be constructed using pre-engineered, pre-cast reinforced concrete base sections, extended base sections, riser sections, cone sections to simplify field installation for all manholes installed in Harnett County. All manholes shall meet or exceed the ASTM standards and these specifications herein for the concrete, structural design, polypropylene reinforced steps, butyl-rubber mastic seal and wraps for water tightness. The pre-cast concrete sections that form the manhole assembly shall be designed to conform to the latest standards established by the North Carolina Department of Transportation (NCDOT) and to support the HS-25 loading for vehicular traffic. Manholes shall be manufactured utilizing wet cast concrete and cast-in style boots for each pipe entering the manholes. Manholes shall be provided by local manufacturers where practical and Harnett Regional Water approves the use of manholes manufactured by Stay Right, Carolina Precast or approved equal. The cast ring and cover assemblies shall be manufactured and supplied by domestic manufacturers and suppliers not foreign companies. Harnett Regional Water prefers to support local businesses and companies where practical. Foreign manufacturers and suppliers are not approved by the HRW for manhole ring and cover assemblies. Manholes may be formed and poured on site if the completed concrete structure meets or exceed the structural integrity of the manholes assembled using the pre-engineered, pre-cast reinforced concrete base sections, extended base sections, riser sections, cone sections conforming to the following applicable ASTM standards:

A36/A36M Specification for Carbon Structural Steel
A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement
A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement
A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement **A706/A706M** Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement **C33** Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Standard]
C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Metric]
C150 Specification for Portland Cement
C260 Specification for Air-Entraining Admixtures for Concrete
C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile
C595 Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
C822 Terminology Relating to Concrete Pipe and Related Products
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1116 Specification for Fiber-Reinforced Concrete and Shotcrete
and Section 5.4.1 d above for reinforced concrete pipe (RCP).

Any work to construct manholes by forming and pouring on site shall be directly supervised by the Professional Engineer (P.E.).

Section 6.4 Manholes

6.4.1 Location

Manholes shall be installed and constructed at the prescribed stations and elevations per the project plan and profile as designed by the Professional Engineer (P.E.) using pre-fabricated, pre-formed concrete manhole barrel, cone and riser sections. Manholes shall be installed at the end of each line and at all intersections. Manholes shall not be installed at distances greater than 400 feet (121.92 m). Any plans that indicate the manholes are more than 400 feet apart should be identified during the pre-construction conference and the location of these manholes will be approved by the HRW in writing prior to construction. Otherwise the manholes should not be installed more than 400 feet apart. Manholes shall be installed square and plumb to be flush with the finished grade when installed in the streets, sidewalks, parking lots. Otherwise the manholes shall be installed square and plumb to an elevation at least two (2 ft.) feet above finished grade or at least two (2 ft.) feet above the 100 year flood plain. Cleanouts may be used only for sanitary sewer service laterals and special conditions approved by HRW. Cleanouts shall not be substituted for manholes nor installed at the end of laterals greater than 100 feet (45.72 m) in length.

6.4.2 Drop Pipe

A drop structure manhole may be installed in accordance with plans and profiles designed by the Professional Engineer (P.E.) and approved by the HRW Engineer. Drop structure manholes must be installed to satisfy these specifications and be constructed with manholes having a diameter of five (5 ft.) feet or greater for inside drops. Drop pipes shall be installed in such a manner to secure the inside drop pipe to the manhole wall without blocking the access in or from the manhole invert. Inside drop connections must be secured with stainless steel straps and bolts. A drop pipe should be installed to keep the flow of wastewater directed toward the invert out without impeding the interior area more than necessary in order to allow room for future connections to the manhole.

Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches (61 cm), the invert of the transition should be filled to prevent solids deposition and the contractor shall cut a small cross section of eight (8) inch PVC pipe and imbed it in the invert slope by grouting it in place to form a PVC pipe slide in the transition area. All other areas surrounding the invert should be tapered to drain toward the invert out and the interior of the manhole shall be coated and sealed with coal tar epoxy, Flex-Seal Utility Sealant ™, Spectrashield Liner ™ or HRW approved equal as outlined herein these specifications and the plan details.

Drop structure manholes constructed with an outside drop connection shall require a manhole with a diameter of at least 48 inches or greater. Outside drop structure manholes shall incorporate a tee with a removable plug to allow the HRW Collections staff to clean the tee on a routine basis. Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete for all outside drop structure manholes. The HRW Utility Construction Inspector must inspect and approve all pipe work for a drop structure manhole prior to concrete encasement of the drop pipe.

6.4.3 Diameter

The minimum diameter of manholes shall be 48 inches (1.22m) larger diameters are preferable for large diameter sewers. A minimum access diameter of 24 inches (61 cm) shall be provided. Larger diameter manholes shall be required for all inside drop structure manholes and where sanitary sewer force mains discharge. Any deviations must be approved by the Professional Engineer and the HRW Engineer in writing before other manholes may be ordered, delivered or installed on the project site.

6.4.4 Flow Channel

The flow channel through manholes should be made to conform in shape and slope to that of the sewers. Change in direction of the channel shall not be less than 90o between the invert in and the invert out without prior approval of the HRW Engineer. The manhole flow channel shall be pre-formed by the manhole manufacturer where practical. Otherwise, the contractor may form the invert channel with brick and blocks being grouted in place. The contractor shall request the approval of the brick and block work prior to grouting the flow channel in the invert of the manhole if the flow channel is not constructed using a pre-formed channel from the manhole manufacturer. Adequate time shall be provided for curing grout work before scheduling the air/vacuum tests to avoid disturbing the invert flow channel.

6.4.5 Exterior Sealing for Water-Tightness

All manholes shall be waterproofed to prevent inflow and infiltration. The inlet and outlet pipes shall be joined to the manhole with a cast in place booted gasket and secured with stainless steel clamps. Manhole frame and covers shall be minimum 310 lbs. in weight and shall be cast from domestic foundries. Each joint between every manhole section shall be sealed with an external rubber sleeve (similar to Mac-Wrap, Infi-Shield Gator Wrap as manufactured by Sealing Systems, Inc) or approved equal. The seal shall be made of a stretchable, self-shrinking, intra-curing halogenated based rubber with a minimum thickness of 30 mils. The back side of each unit shall be coated with a cross-linked re-enforced butyl adhesive. The butyl adhesive shall be non-hardening sealant, with a minimum thickness of 30 mils. The seal shall be designed to stretch around the substrate then overlapped creating a cross-link and fused bond between the rubber and butyl adhesive. The application shall form a continuous rubber seal that applies inward pressure on the protected area for the life of the application. The butyl adhesive and the inward pressure exerted on the substrate will prevent the intrusion of water and soil through the joint sections of a manhole, catch basin or concrete pipe. External rubber sleeve shall be UV and Ozone resistant and it shall meet or exceed the following:
Sheer Strength shall be 20 psi minimum per ASTM test method D816
Tensile Strength shall be 50 psi minimum per ASTM test method D412
Elongation % shall be 500 % per ASTM test method D412
Penetration shall be 60/140 MM minimum per ASTM test method D217
Low temperature shall be -49° F flexibility per ASTM test method D746
Heat aging, the material shall be able to withstand 90°C for 7 days and be able to reach 300% elongation at break and have a minimum tensile strength of at least 100 psi.

6.4.6 Interior Sealing for Water-Tightness

A. No-Flow (HDPE) Manhole Inserts

A No-Flow, dish type insert shall be installed in the top of each manhole that is installed within a paved street, driveway, parking lot, concrete sidewalk or any other impervious surface when the manhole cover will be flush with the finished grade and located at the lowest point in the project where the potential for inflow is the greatest. The dish inserts shall be constructed of an ultra high density polyethylene copolymer material that meets ASTM Standard D1248, Class A, Category 5, Type III with a minimum impact brittleness temperature of less than -131°F. The thickness shall be uniform 1/8” or greater. The material shall be corrosion proof from all gases associated with waste water collection systems and the inserts will include the following:

1. Lift Strap – The lift strap shall be made of a woven polypropylene web material attached to the bowl of the dish by a wide head stainless steel rivet with a stainless steel backup washer ¾" in diameter. All cut edges shall be seared to prevent unraveling.

2. Vent – ventilation shall be provided by a 1/8" hole and/or a valve located on the side of the bowl. The hole or the valve shall allow a maximum release of 10 gallons of water per 24 hours and shall not be affected by debris that can collect at the bottom of the dish. Sewer gases shall be vented at one (1 psi) pound per square inch or less.

3. Density – The density shall be at least fifty-nine (59 lbs. /ft3) pounds per cubic foot and conforming to ASTM D1505.

4. Tensile Strength – The tensile strength shall be 3,600 psi and conforming to ASTM D638 Type IV.

5. Brittleness Temperature – The brittleness temperature shall be greater than or equal to -131°F and conforming to ASTM D1505.

B. Internal Manhole Seals

Manhole seal shall be designed to prevent leakage of water into the manhole through the frame joint area and the area above the manhole cone including all extensions to the chimney area. Extensions shall include but is not limited to lifting rings, brick and/or block material that may have been used to achieve grade. The seal shall remain flexible allowing for the repeated vertical or horizontal movements of the frame due to frost lift, ground movement or the thermal movement of pavements. The final liner material shall be made no less than 170 mils of corrosion resistant aromatic flexible urethane resin coating to be applied to the inside wall of the entire chimney area as described above. The product shall have a minimum elongation of 800% and hardness (Durometer) of 75. Final liner shall have a minimum tensile and adhesion strengths of 1150 psi and 175 lb. l/in. respectively. The manhole sealing system shall conform to the physical requirements of ASTM D- 412. The lining product shall have an aromatic urethane primer resin on the complete surface. The sealing system shall line the interior of the adjustment area from the cone/top of the manhole and onto the inside of the casting. If the manhole has been relined prior to the seal installation the seal shall cover a minimum of 12 vertical inches or a minimum of 1 kit.

All loose and protruding mortar and brick that would interfere with the seal's performance shall be removed. Any lips for gravel pan supports shall be cut off flush with casting. Patching cement shall conform to requirements of the manufacture. Any profiling cement work will require the contractor to contact the sealant manufacture to determine in writing the proper time required for the cement to completely cure prior to installing this item. Preparation of the surface should include sandblasting (minimum of 70CFM) and an acetone wet wipe to ensure a clean surface as required by manufacture. Active leaks (infiltration) must be corrected by a method approved by the HRW Engineer prior to installing an Internal Manhole Seal. The substrate surface must be free of sand, loose debris, latencies, dust, oil, grease or chemical contamination. A blower or torch may be required to completely dry the substrate surface or as recommended by the manufacturer. Flex-Seal Utility Sealant or approved equal may require the proper mixing of agents, as recommended by the manufacturer's instructions. Ensure casting and structure surfaces are clean and dry where the primer is intended to adhere. After allowing for proper drying of primer to occur, sealant may be applied by brush as evenly as possible over the entire chimney area that includes the frame joint area and the area above the manhole cone including all extensions to the chimney area. The contractor is to furnish the HRW Utility Construction Inspector Engineer two (2) mirrors with extension handles that can be used to inspect sealant application to areas underneath frame without entry of manhole. These items will become the property of HRW upon completion and at no additional cost of this item. Cost for these items shall be included in the bid items for internal manhole sealing work.

6.4.7 Interior Coating for Manholes Receiving Wastewater Discharge from a Force Main

Where force mains are discharged to manholes, such manhole interior shall be adequately protected with a HRW approved coating to prevent hydrogen sulfide damage. The interior coating shall be either coal tar epoxy, Flex-Seal Utility Sealant ™, Spectrashield Liner ™ or HRW approved equal. The Spectrashield Liner ™ must be applied by the manufacturer's authorized representative due to the trademark rights, proprietary, legal and quality control reasons due to the special heat application equipment. The Flex-Seal Utility Sealant manufactured by Sealing

Systems, Inc. may be applied by any competent contractor once certified by the manufacturer and the sealant must be applied at ambient temperatures at 45° F or higher with minimal humidity in the atmosphere for ideal application conditions. The sealant must be applied by brush to achieve a sealant layer of at least 170 mils thick. The manufacture must in writing certify that each of the contractor's representatives are approved to install Flex-Seal Utility Sealant or approved equal for this item. The training shall be included in the bid items for internal manhole seals. The appropriate certification by the manufacturer must be provided for each contractor that will apply the sealant to the manholes. The contractor shall submit shop drawings in accordance with the General Contract Conditions. The manufacturer's specifications for the materials and method for proposed installation of this item shall be submitted to the HRW Engineer for the approval before internal sealing work commences.

6.4.8 Paved and Unpaved Roads

When manholes are placed in unpaved roads, the top of the manhole shall be 4 inches below grade of the road and constructed in order that the manhole may be lowered 6 inches by including a riser section above the cone section and below the ring and cover. The riser section may be removed and replaced with a different riser section in the future to adjust the manhole rim elevation to the finished grade of the road should it be paved in the future.

6.4.9 Final Adjustment to Finished Grade with Rubber Riser Rings

Foe manholes located in the paved streets and parking lots subject to vehicular traffic, rubber riser ring sections shall be located between the cone section of the manhole and the cast ring and cover assembly and it shall be bolted down through the ring into the last concrete riser section. The rubber riser will reduce vibration from the vehicular traffic and will protect the structural integrity of the manhole assembly below the finished grade of the street.

When manholes are placed in paved roads, the top of the manhole shall be installed to be flush with the finished grade of the street including the rubber riser ring that can vary from ½ inch to 3 inches. During construction process the top of the cone section of the manhole shall have at least 48 square inches of concrete poured around it to keep it stable prior to paving the street or parking lot. This will keep the structure in placed should the paving contractor bump the top of the manholes ring and cover. The concrete shall be formed and poured to at least six (6") inches below finished grade of the road. The concrete poured in the form around the top of the riser section shall be rated for at least 3,000 psi or greater. Manholes shall be adjusted to finished grade using Infi-Shield Uni-Band manhole adjustment rings or approved equal. The Uni-Band seal manhole sealing system shall be installed to prevent leakage of water into the manhole through the frame joint area and through the adjustment ring area. All sealing materials required for the installation of the Uni-Band manhole sealing system shall be furnished by the contractor and shall be new, of first grade, and shall be of reputable domestic manufacturers. The frame or ring casting shall be sealed to the concrete manhole structure with a Uni-Band sealing system as manufactured by Sealing Systems, Inc. or approved equal. The seal shall be a continuous seamless band made of high quality EPDM (Ethylene Propylene Diene Monomer) rubber with a minimum thickness of 65 mils. There shall be a preformed L shaped corner molded into the top of the seal. The top section and the side section will extend from the L shaped corner at a generally 90-degree angle to each other. Wherein the seal is pre-formed in substantially the same shape as when attached to the manhole structure, the thickness of the L shaped corner extending 1" into the top section and 1" down the side 89 section is increased and may be at least twice the thickness of the top section reinforcing the seal at this particular area. There shall be a 2" to 3" wide strip of butyl mastic attached to the underside of top section of the seal. There shall be a 2" wide strip of butyl mastic attached to the inside of the side section at the bottom of the seal. The mastic shall be non-hardening butyl rubber sealant, with a minimum thickness of 1/8", and shall seal to the cone/top of the manhole section and over the flange of the casting frame. An aerosol primer shall be used to enhance the bond strength of the seal to the structure. The Uni-Band seal sealing system shall be installed according to the manufacturer's recommendations. The top section of the seal shall extend up from ½" to 3" (in ½" sections) attaching to the casting base/flange with the side section covering over the entire grade adjustment ring area and onto the cone section a minimum of two (2") inches.

6.4.10 Main Line Location

In both public and private road right-of-ways, main line sewers shall be located in accordance with the HRW specification and NCDOT standards. A minimum permanent easement width of 20' shall be provided where it is necessary to install main line sewer outside of public highway right-of-ways, such as planned unit developments, private road right-of-ways and commercial areas, etc. or a combination of 15' common property easement and 15' building setback for lines installed between adjacent parcels.

6.4.11 Patching and Paving

Roadway patching and paving shall be in keeping with the latest edition of the standards established by North Carolina Department of Transportation (NCDOT). Under no circumstances shall open cuts in the existing state maintained roadways remain unpaved or patched in keeping with highway standards for more than 2 days. Failure on the part of the contractor to take adequate action on patching will force Harnett Regional Water to sublease a paving contractor for the repairs. The contractor will be billed for such work and project acceptance will be subject to payment for repairs as required by the NCDOT.

Section 6.5 Access

Access steps shall be provided in all manholes, concrete vaults and concrete structures. The access step shall be so located to be easily reached by the HRW staff for simple means of entry. Steps shall be of a non-corrosive material such as polypropylene per HRW Standard details. The manhole ring and cover shall not be less than 24” in diameter to provide adequate room for access to the manhole interior. The distance from the finished grade to the first step shall not exceed 24 inches.

Section 6.6 Pipe Connections to Existing Manhole

Pipe connections to existing manholes shall be made in such a manner that the finished work will conform as nearly as practical to the essential requirements specified for new manholes, including all necessary concrete work, cutting and shaping. The connection shall be at a right angle target (centered) to the manhole. Holes for the new pipe shall be large enough to facilitate a Harnett Regional Water approved rubberized water stop and allow packing cement mortar around the entire periphery of the pipe but no larger than 1-1/2 times the diameter of the pipe. No manhole may be core drilled until a representative of HRW may be present to witness the drilling operation, pipe installation and sealing of the new opening in the manhole wall. All openings of existing manholes shall be properly sealed once the new sewer pipe has been installed to grade and fit position within the manhole structure.

Section 6.7 Sanitary Sewer Service Laterals

6.7.1 Residential Sewer Service Lateral Connections

A. Materials

4" Polyvinyl Chloride (PVC) - All pipe fittings shall conform to latest edition ASTM D 1785, Schedule 40.

6" Polyvinyl Chloride (PVC) - All pipe and fittings shall conform to latest edition ASTM D 3034, SDR 35.

B. Clean Out Location

Residential sanitary sewer service laterals shall not be less than four (4”) inches or greater than six (6”) inches (Polyvinyl Chloride ASTM D 3034). A clean out sized to match the sanitary sewer lateral shall be provided as specified in the project plans to be positioned within one (1 ft.) foot inside the right-of-way or utility easement. The cleanout cap shall be bronze, ductile or cast iron with an 18" x 18" x 4 or an 18” x 18” x 6" concrete collar to protect the clean out. The concrete collar shall be installed to finished grade and the clean out cap shall be between 1”-2“ below the top of the concrete collar. This cleanout establishes the point of termination for maintenance responsibility by Harnett Regional Water. In case of easements, a terminal cleanout shall be provided not greater than 10 feet from center line of sanitary sewer main. All sanitary sewer clean outs shall be designed to be positioned at least one (1 ft.) foot inside the right-of-way or utility easement. The cleanout stack shall be designed to be at least two (2 ft.) feet above finished grade and capped with a temporary cap until the plumber can make the connection to the building and lower the clean out to the finished grade. . No sanitary sewer service lateral shall be connected to any manhole unless approved by the HRW in writing.

Field Measurements: The contractor shall keep a log of field measurements while the sewer main and laterals are installed to measure the following distances:

- The distance L-1between the downstream manhole and the in-line wye fitting for each residential sanitary sewer service lateral,

- The distance L-2between the in-line wye fitting on the sanitary sewer main to the sanitary sewer clean out for each residential sanitary sewer service lateral,

These measurements must be provided to the Professional Engineer (P.E.) at the conclusion of the project to be documented in the As-Built Record Drawings to be provided to the HRW Engineer.

6.7.2 Grease Traps

All grease traps shall be installed in accordance with the project plans and profiles as designed by the Professional Engineer (P.E.) and approved by the HRW. The contractor shall notify the HRW Utility Construction Inspector and the HRW Pretreatment Coordinator of the scheduled installation date at least 24 hours in advance of installation to allow the HRW staff an opportunity to inspect the grease trap prior to installation. All grease traps shall be manufactured in conformance ASTM standards, including but, not limited to the elements and components of reinforced concrete structures as follows:

A36/A36M Specification for Carbon Structural Steel
A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement
A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement
A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement **A706/A706M** Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement **C33** Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Standard]
C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [Metric]
C150 Specification for Portland Cement
C260 Specification for Air-Entraining Admixtures for Concrete
C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile
C595 Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
C822 Terminology Relating to Concrete Pipe and Related Products C989 Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1116 Specification for Fiber-Reinforced Concrete and Shotcrete

Section 6.8 Easements

In all cases where it is necessary to construct sewer mains crossing private property, an easement designated specifically for the construction, operation and maintenance of water/sewer improvements shall be dedicated exclusively to the County of Harnett. Dimensions of the easement shall be in keeping with the herein stated separation requirements. A minimum permanent easement width of 20‟ shall be provided where it is necessary to install a sanitary sewer main outside of public highway right-of-ways, such as planned unit developments, private road right-of-ways or commercial areas, the easement shall be at least 30 feet wide to include a combination of 15' common property easement and 15' building setback for lines installed between adjacent parcels.

All construction shall be kept within the temporary construction easement outlined in the plans designed by the Professional Engineer (P.E.) and as staked out by the Registered Land Surveyor (R.L.S.). All easements must be graded to finished grade in accordance with the plans and profiles. The easements must be seeded and covered with straw or tacked down to establish vegetative growth over the entire easement before the construction project ends. If the vegetative growth has not been established as required the contractor shall repeat the seeding process again until the vegetative growth is established at no additional cost to the HRW.

Section 6.9 Protection of Water Supplies

6.9.1 Water Supply Interconnections

The contractor shall not make any physical connections between a public or private potable water supply system and a sewer or other non-potable water source (irrigation), or appurtenance which would permit the passage of any sewage or polluted water into the potable water supply. No water pipe shall pass through or come in contact with any part of a sewer manhole.

6.9.2 Relation to Water Works Structures

A. Horizontal and Vertical Separations

The Contractor shall install the sanitary sewer improvements in accordance with plans and profiles as designed by the Professional Engineer (P.E.) maintaining the proper horizontal and vertical separations outlined in these specifications under Section 5.4 and as approved by the HRW Utility Construction Inspector. The sanitary sewer lines shall be laid at least 10 feet (3.0m) horizontally and at least 24 inches (61 cm) vertically from any existing or proposed potable water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten foot separation, Harnett Regional Water may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the sewer closer to the water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the sewer and at an elevation so that the bottom of the water main is at least 18 inches (46 cm) above the top of the sewer and both water and sewer main are constructed of ferrous pipe materials. The Engineer shall provide additional details for such installation in addition to the HRW Standard Details.

B. Crossings

Sanitary sewer lines crossing potable water mains shall be laid to provide a minimum vertical distance of 24 inches (61 cm) between the bottom (outside) of the water main pipe above the top (outside) of the sanitary sewer main. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water joints, preferably ten (10ft.) feet from the center of the crossing. In cases where it is not practical to maintain a vertical distance of 24 inches (61 cm) separation, Harnett Regional Water may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the sewer closer to the water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the sewer and at an elevation so that the bottom of the water main is at least 24 inches (61 cm) above the top of the sewer and both water and sewer main are constructed of ferrous pipe materials. The Engineer shall provide additional details for such installation in addition to the HRW Standard Details.

C. Special Conditions

When it is impossible to install the sanitary sewer lines with the proper horizontal and vertical separations as stipulated above, the sanitary sewer shall be constructed of ferrous pipe materials equal to the water pipe and shall be pressure tested to assure water-tightness prior to backfilling. Where these separations cannot be maintained then the sanitary sewer main and the potable water main shall be installed with ductile iron pipe and the minimum vertical separation of eighteen (18”) shall be maintained at the crossing or a minimum of five feet shall be maintained horizontally.

Section 6.10 Pipe Installation Standards and Procedures

6.10.1 Standards

Installation specifications shall contain appropriate requirements based on the criteria, standards and requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and back filling thereof so as not to damage the pipe or its joints, impede cleaning and future tapping nor create excessive side fill pressures or ovulation of the pipe, nor seriously impair flow capacity.

6.10.2 Trenching

A. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the backfill to be placed and compacted as needed to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are dug, appropriate bedding class and pipe strength shall be used.

B. Boulders, large stones, and other large materials shall be removed to provide a minimum clearance of 12 inches (30 cm) below and on each side of all pipe(s).

C. All organic material shall be removed from the sub base of the trench.

6.10.3 Bedding

A. Bedding classes A, B, or C, as described in ASTM C1274 (ANSI A 106.2) or WPCF MOP NO. 9 (ASCE MOP NO 37) shall be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load.

B. Bedding Class I, 1/4 inch to 1-1/2 inch graded stone bedding, as described in ASTM D 2321 (ANSI K 65.171) shall be used for all flexible pipe will be installed in bedding placed four (4) inches below the pipe barrel and brought up to the top of the pipe. Class I, II, or III materials will be used for initial backfill up to six (6) inches above the top of the pipe over the full width of the trench.

6.10.4 Backfill

A. Backfill shall be of suitable material removed from excavation except where other material is specified. Debris, frozen material, large clods or stones, organic matter, or, other unstable material shall not be used for backfill. Backfill will be hand tamped or pneumatically tamped to twenty-four (24) inches above the top of the pipe. Backfill to the top of ground will be in eight (8) inch loose thickness lifts compacted. Compaction density shall be a minimum of 95% standard proctor under all paved areas and 90% standard proctor in all other areas. Compaction testing as approved by the HRW shall be provided in all paved areas.

B. Backfill shall be placed in such a manner as not to disturb the alignment of the pipe. Any pipe displaced or broken during backfilling or compaction will be replaced.

6.10.5 Deflection Test

A. Deflection tests shall be performed on all pipe (100%). The test shall be conducted after the final backfill has been in place at least 15 days. The mandrel and proving ring will be furnished by the contractor.

B. No pipe shall exceed a deflection of 5%, calculated by using the base inside diameter as furnished by ASTM.

C. If the deflection test is to be run using a rigid ball or mandrel, it shall have a diameter equal to 95% of the inside diameter of the pipe. The test shall be performed without mechanical pulling devices. The contractor is responsible for providing mandrel and associated equipment at the time of inspection. The latest applicable ASTM standard for the mandrel shall be used by the contractor.

Section 6.11 Joints and Infiltration

6.11.1 Joints

The installation of joints and the materials used shall be included in the specifications. Sewer joints shall be installed to minimize infiltration (100 gpd/inch diameter of pipe/mile or less) and to prevent the entrance of roots throughout the life of the system. Junctions of dissimilar pipes or junctions requiring some form of rubberized banding material shall be totally encased with a minimum of 6" of concrete surrounding the junction for a distance of 2' either side of the end of the banding material.

6.11.2 Leakage Tests

Leakage tests shall be required for all main line sewers and shall include installed services. Such tests shall be by the low pressure air testing method. The air test shall, at a minimum, conform to the test procedure described in the last edition of ASTM. The testing methods selected should take into consideration the range in groundwater elevations projected and the situation during the test.

6.11.3 Inspection

The specifications shall include a requirement for inspection of manholes for water-tightness prior to placing into service. Prior to inspection, all lines must be flushed and cleaned.

Section 6.12 Flushing and Cleaning

Flushing and cleaning shall be the responsibility of the contractor. The contractor shall pump dry and dispose of all extraneous ground water and other sand, gravel and foreign objects within the sewer main. Such material shall not be flushed into the existing operating sewer mains, pump stations, or pertinent facilities. Flushing of main line sewers under construction into main lines of Harnett Regional Water is prohibited. Water for flushing and cleaning, as herein referenced, shall be provided by the HRW upon payment of appropriate fees for the installation of a fire hydrant meter in keeping with HRW established standards, rates and regulations to meter all water usage. The water used for road construction must be kept separate from the water used in the construction, cleaning, flushing and of the sanitary sewer system improvements for billing purposes.

Section 6.13 Main Line Location

In both public and private road right-of-ways, main line sewers shall be located in accordance with the HRW. A minimum permanent easement width of 20' shall be provided where it is necessary to install main line sewer outside of public highway right-of-ways, such as planned unit developments, private road right-of-ways and commercial areas, etc. or a combination of 15' common property easement and 15' building setback for lines installed between adjacent parcels.

Section 6.14 Patching and Paving

Roadway patching and paving shall be in keeping with the latest edition of the standards established by North Carolina Department of Transportation (NCDOT). Under no circumstances shall open cuts in the existing state maintained roadways remain unpaved or patched in keeping with highway standards for more than 2 days. Failure on the part of the contractor to take adequate action on patching will force Harnett Regional Water to sublease a paving contractor for the repairs. The contractor will be billed for such work and project acceptance will be subject to payment for repairs.

Section 6.15 Aerial Crossings

Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning and settlement. Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above ground and below ground sewers. For aerial stream crossings, the bottom of the pipe should be placed no lower than the elevation of the 100-year flood plain per the plans and profiles designed by the Professional Engineer (P.E.). The P.E. shall specify any and all special fittings, hangers, brackets, or supports that may be required for the aerial crossing and provide details of such special fittings, hangers, brackets, or supports in the project plans. 94

Please see Chapter 12, General and Special Conditions, Section Special Construction Technical Specifications for additional information and requirements for construction.

SECTION 33 42 11

STORMWATER GRAVITY PIPING

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

A. Section 01 33 00 – Submittals: Shop Drawings, Product Data, and Samples

B. Section 31 11 00 – Clearing and Grubbing

C. Section 31 23 00 – Earth Moving: Excavation and Fill

D. Section 31 23 33 – Excavation, Trenching, and Backfilling for Utilities Systems

1.2 SUMMARY

A. This section includes gravity flow storm drainage outside the building, with the following components:

1. Drainage piping, fittings, and accessories

1.3 REFERENCE STANDARDS

1.3.1 American Association of State Highway and Transportation Officials (AASHTO)

A. ASHTO LRFD Bridge Construction Specifications: Section 27 – Concrete Culverts

B. AASHTO LRFD Bridge Construction Specifications: Section 30 – Thermoplastic Pipe

C. AASHTO M170 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

D. AASHTO M 242 Standard Specification for Reinforced Concrete D - Load Culvert, Storm Drain, and Sewer Pipe

E. AASHTO M315 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

F. AASHTO M330 Polypropylene Pipe 300 - 1500-mm (12-to 60-in.) Diameter

G. AASHTO R 16 Regulator Information Used in AASHTO Test

H. AASHTO R 82-17 Standard Practice for Pipe Joint Selection for Highway Culvert and Storm Drains

I. AASHTO T99 Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12- in.) Drop

J. AASHTO T341 Determination of Compression Capacity for profile Wall pipe by Stub Compression Loading

1.3.2 American Society for Testing and Materials (ASTM)

A. ASTM A615 – Standard Specification for Deformed and Plain Carbon- Steel Bars for Concrete Reinforcement.

B. ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

C. ASTM C150 – Standard Specification for Portland cement.

D. ASTM C260 – Standard Specification for Air--Entraining Admixtures for ASTM Concrete.

E. ASTM C361 – Standard Specification for Reinforced Concrete Low-- Head Pressure Pipe.

F. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

G. ASTM C655 – Standard Specification of Reinforced D--Load Culvert, Storm Drain and Sewer Pipe.

H. ASTM C827 – Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.

I ASTM C924 – Standard Practice for Testing Concrete Pipe Sewer Lines by Low-pressure Air Test Method

J. ASTM C969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

K. ASTM C990 – Standard Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

L. ASTM C1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

M. ASTM C1417 – Standard Specification for Reinforced Concrete Sewer, Storm Drain and Culvert Pipe for Direct Design.

N. ASTM C1479 – Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installation.

O. ASTM C1619 – Standard Specifications for Elastomeric Seals for Joining Concrete Pipe.

P. ASTM C1628 – Standard Specifications for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets.

Q. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

R. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

S. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

T. ASTM F1417 – Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air

U. ASTM F2487 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High-Density Polyethylene Pipelines

V. ASTM F2764 – Standard Specification for 6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-pressure Sanitary Sewer Applications

W. ASTM F2881 – Standard Specification for 12 to 60 in. [300 to 1500 mm] Polypropylene (PP) Dual Wall Pipe and Fittings for Non-pressure Storm Sewer Applications

X. ASTM F3058 – Standard Practice for Preliminary Field Testing of Thermoplastic Pipe Joints for Gravity Flow (Non--Pressure) Sewer Lines

1.4 DEFINITIONS

A. PP – Polypropylene Pipe

B. RCP – Reinforced Concrete Pipe

C. Piping System – All products associated with the drainage system including but not limited to pipe, fittings, drainage structures, geotextile, best management practice products and storage systems.

1.5 PERFORMANCE REQUIREMENTS

All pipe supplied shall meet the minimum joint performance requirements as defined herein and as further defined in the joint performance requirements of this specification.

A. Watertight Gravity--Flow, Non--Pressure, Drainage--Piping shall be in accordance with ASTM C361, ASTM C443 or ASTM C1628 for RCP, and ASTM D3212 for PP as appropriate per pipe material.

B. Pipe fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations, and in a way that they meet or exceed joint performance standards found in ASTM C361, ASTM C443 or ASTM C1628 for RCP, and ASTM D3212 for PP.

1.6 SUBMITTALS

The following shall be submitted by contractor in accordance with Section 01 33 00 Submittal Procedures:

A. Product Data for the following:

1. Pipe and Fittings

2. Product specifications

3. Installation procedures

B. Products submitted as approved equal must be submitted at least two (2) weeks prior to project bid opening and must be approved by project engineer. Submittal for approved equal product must contain a signed letter from an executive officer of the manufacturer stating product is equivalent to all applicable requirements of this specification.

C. Details of fittings and specials shall be furnished for approval by ENGINEER. Unless otherwise specified, CONTRACTOR shall submit to ENGINEER for approval SHOP DRAWINGS showing the exact dimension of the joints including the permissible tolerances for each size of pipe being furnished and the size, type and locations of gasket materials. Approval of the joint detail DRAWINGS shall not relieve CONTRACTOR of any responsibilities to meet all of the requirements of these SPECIFICATIONS, or of the responsibility for correctness of CONTRACTOR's details.

D. At the request of the ENGINEER, the CONTRACTOR shall cooperate in obtaining and providing samples of all specified materials.

E. At the request of the ENGINEEER, the CONTRACTOR shall submit certified laboratory test certificates for all items required in this section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. All pipe and fittings shall be delivered to the site and unloaded with handling that conforms to the manufacturer's instructions for reasonable care. Pipe shall not be rolled or dragged over gravel or rock during handling. The Contractor shall take necessary precautions to ensure the method used in lifting or placing the pipe does not induce undue stress fatigue in the pipe.

B. Responsibility for Material:

1. CONTRACTOR shall be responsible for all materials intended for the WORK that are delivered to the construction site and accepted by CONTRACTOR. Payment shall not be made for materials found to be defective or damaged in handling after delivery and acceptance. Defective or damaged materials shall be removed and replaced with acceptable materials at CONTRACTOR's expense.

2. CONTRACTOR shall be responsible for the safe and proper storage of such materials.

C. Pipe Acceptance:

1. RCP – In addition to any deficiencies not covered by ASTM C76 or ASTM C361 pipe which has any of the following visual defects, will not be accepted.

a. Pipe, which has been patched to repair porous spots, cracks, or other defects, when such patching was not approved by ENGINEER.

b. Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.

c. Pipe that has been damaged during shipment or from handling even if previously approved before shipment.

d. Concrete pipe, at delivery to the job site, shall have cured and reach the design strength as required by ASTM C76, ASTM C361 and be at least three (3) days (seventy-two [72] hours) old.

2. PP – In addition to deficiencies not covered by ASTM F2764, ASTM F2881, or AASHTO M330 pipe which has any of the following visual defects, will not be accepted.

a. Pipe with cracks, structural dents, or delamination, when not approved by ENGINEER.

b. Pipe that has been damaged during shipment or from handling even if previously approved before shipment.

c. Acceptance of the pipe at point of delivery shall not relieve CONTRACTOR of full responsibility for any defects in materials due to workmanship.

D. Pipe Handling:

1. Pipe and accessories furnished by CONTRACTOR shall be delivered to, unloaded, and distributed at the site by CONTRACTOR. Each pipe shall be unloaded adjacent to or near the intended laying location.

2. Pipe fittings, specials, valves, and appurtenances shall be unloaded and stored in a manner that precludes shock or damage. Such materials shall not be dropped.

3. Pipe shall be handled in a manner intended to prevent damage to the pipe ends or to any coating or lining. Pipe shall not be skidded or rolled against adjacent pipe. Damaged coatings or lining shall be repaired by CONTRACTOR, at CONTRACTOR’s expense, in accordance with the recommendations of the manufacturer and in a manner satisfactory to ENGINEER. Physical damage to the pipe or accessory shall be repaired by CONTRACTOR, at CONTRACTOR’s expense, and in a manner satisfactory to ENGINEER.

4.Gasket Storage: All gaskets shall be stored in a cool place, preferably at a temperature less than seventy degrees Fahrenheit (70°F.), and in no case shall the gaskets be stored in the open, or exposed to the direct rays of the sun.

PART 2 — PRODUCTS

2.1 CORRUGATED POLYPROPYLENE (PP) PIPE

2.1.1 General

A. 12--inch through 60-inch (300 through 1500 mm) pipe shall be smooth interior and annular exterior corrugated polypropylene (PP) pipe meeting the requirements of ASTM F2764, ASTM F2881 or AASHTO M330 Type S (double-wall) or D (triple-wall), for respective diameters.

B. Material for 12-- through 60--inch pipe and fitting production shall be an impact modified copolymer meeting the material requirements of ASTM F2764, ASTM F2881 and AASHTO M330, for respective pipe diameters.

C. Marking: The following shall be clearly marked on both the interior and exterior surface of the pipe:

1. Appropriate ASTM Specifications: ASTM F2764, ASTM F2881 or AASHTO M330, as appropriate.

2. Class, size, and wall.

3. Date of manufacture.

4. Name or trademark of manufacturer.

5. Diameter of Pipe: The diameter indicated on the DRAWINGS shall mean the inside diameter of the pipe.

2.1.2 Joint Performance

A. Watertight joints shall be bell-and-spigot meeting the watertight requirements of ASTM D3212. Gaskets shall comply with the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

2.1.3 Fittings

A. Fittings shall conform to ASTM F2764, ASTM F2881 or AASHTO M330, with the exception of meeting the watertight joint performance requirements of ASTM D3212. Gasketed bell & spigot connections shall utilize a spun-on, welded or integral bell and spigot with gaskets meeting ASTM F477.

B. Repair couplers may be utilized to connect field-cut pipe.

2.2 REINFORCED CONCRETE PIPE (RCP)

2.2.1 General

A. Precast concrete pipe, which does not conform to ASTM C76 pipe, ASTM C361 or to any other requirement specified herein, shall not be approved for storm sewer or culvert installations.

B. Allowable ASTM Specifications: All material, manufacturing operations, testing, inspection, and making of concrete pipe shall conform to the requirements of ASTM C76 pipe or ASTM C361, the latest revision thereof, listed in Article References.

C. Marking: The following shall be clearly marked on both the interior and exterior surface of the pipe:

1. Appropriate ASTM Specification: ASTM 76 or ASTM C361.

2. Class, size, and wall.

3. Date of manufacture.

4. Name or trademark of manufacturer.

5. Diameter of Pipe: The diameter indicated on the DRAWINGS shall mean the inside diameter of the pipe.

D. Wall Thickness and Class of Pipe: The wall thickness and reinforcing steel, if any, shall comply with ASTM C76 for pipe or ASTM C361 and the class of pipe designated on the DRAWINGS. No elliptical reinforcing shall be allowed in any circular pipe, unless the top of the pipe is clearly noted, and orientation is verified by the ENGINEER as it is being installed.

E. Class IV RCP shall be used under pavement and shall be a complete run between storm structures; and where coverage over pipe is less than two (2) feet. Class III RCP is allowable in all other applications.

2.2.2 Joint Performance:

A. The joint design for concrete pipe shall have a bell, spigot, and rubber gasket. The spigot shall be single offset or grooved with the gasket placed on the spigot end of the pipe. The bell and spigot shall be accurately formed so that when each pipe section forced together it shall forms a continuous watertight conduit with a smooth and uniform interior surface; and shall provide for slight movement of any piece of the pipeline due to expansion, contraction, settlement or lateral displacement. The gasket shall be the sole element of the joint providing water tightness. The ends of the pipe shall be in planes at right angles of the longitudinal centerline of the pipe. The ends shall be furnished to regular smooth surfaces.

B. Rubber Gasketed Joints: Only rubber gasketed joints will be acceptable for concrete pipe storm sewer installations. All joints and jointing material shall conform to the following minimum requirements.

1. Rubber gasket joints for bell and spigot pipe using a confined gasket joint shall consist of a rubber gasket with an O-ring or circular cross-section and shall conform to the requirements of ASTM C361, ASTM C443, or ASTM C1628 for the designated pipe.

2. Rubber gasket joints for bell and spigot pipe using a single offset joint shall consist of a rubber gasket with a non-circular profile cross-section and shall conform to the requirements of ASTM C361, ASTM C443, or ASTM C1628 for the designated pipe.

3. Gaskets may be natural or synthetic rubber conforming to ASTM C1619.

2.2.3 Fittings

A. Fittings shall be made up of pipe segments having the same structural qualities as the adjoining pipe and shall have the interior/exterior treated the same as the pipe.

B. Lifting Holes: Lifting holes will be allowed for storm sewer pipe provided they are fully grouted using a non-shrink grout after installation and before backfilling the pipe. Only one lifting hole per pipe length and fitting will be allowed.

C. Cement: Unless otherwise required by ENGINEER, or specified otherwise on the DRAWINGS, Type II Modified Portland Cement complying with the requirements of ASTM C150 will normally be acceptable in the manufacture of concrete pipe.

PART 3 — EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling shall be as specified in Section 31 23 00, Excavation and Fill.

3.2 PIPING INSPECTION

3.2.1 General

A. Piping, fittings, and drainage structures shall be inspected prior to installation and any defective or damaged product shall be replaced.

B. Refer to Section 1.7 Delivery, Storage and Handling for pipe & fitting acceptance requirements

3.2.2 Inspection

A. Any pipe, fittings, or drainage structures with cracks, cuts, punctures, or other damage on the interior or exterior shall be rejected and replaced.

B. Any pipe, fittings or drainage structures with damaged ends, joints or gaskets, which would prevent proper sealing of the joints, shall be rejected and replaced.

C. The pipe shall be inspected by ENGINEER for damage or defects before being placed in the trench. Damaged or defective pipe shall not be installed.

D. All pipes that do not meet the requirements of PART 2 of this section will be rejected and replaced at CONTRACTOR's expense.

3.3 PIPING, FITTING, AND DRAINAGE STRUCTURE INSTALLATION

3.3.1 General

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of stormwater gravity piping. Location and arrangement of piping layout take design considerations into account. Install piping system as indicated herein and as directed by the product manufacturer, to extent practical. Where specific installation procedure is not indicated, follow product manufacturer's written instructions.

B. All products shall be inspected for defects and cracks before being lowered into the trench, piece by piece. Any defective, damaged or unsound pipe, fitting or drainage structure or any product that has had its grade disturbed after laying, shall be taken up and replaced. Open ends shall be protected with a pipe plug to prevent earth or other material from entering the pipe during construction. The interior of the pipe shall be free from dirt, excess water and other foreign materials as the pipe laying progresses and left clean at the completion of the installation.

C. Install piping system 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. Follow product manufacturer's instructions for the use of lubricants, cements, and other special installation requirements.

D. Use Manholes or Catch Basins for changes in direction, unless fittings are indicated. Use tap-fittings for branch connections, unless fittings are specified on the drawings.

E. Use 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.

F. For RCP, CONTRACTOR shall install storm sewer pipe of the type, diameter, load class, and wall thickness that is shown on the DRAWINGS. Installation shall be in accordance with Section 27 of The AASHTO LRFD Bridge Construction Specifications or ASTM C1479.

G. For PP, CONTRACTOR shall install storm sewer pipe of the type, diameter, and joint performance that is shown on the DRAWINGS. Installation shall be in accordance with Section 30 of The AASHTO LRFD Bridge Construction Specifications, ASTM D2321, or manufacture recommendations.

H. Proper equipment, implements, tools and facilities shall be provided and used by CONTRACTOR for safe and convenient installation of the type of pipe being installed.

3.3.2 Trench Excavation

3.3.2.1 Excavation

A. Within Easement, Cultivated, Landscaped, or Agricultural Area:

1. All vegetation, such as brush, sod, heavy growth of grass or weeds, decayed vegetable matter, rubbish and other unsuitable material within the area of excavation and trench side storage shall be stripped and disposed of in accordance with the requirements of Section 31 11 00, Clearing and Grubbing.
2. Within Unpaved Roadway Areas: CONTRACTOR shall strip the cover material from graveled roadways or other developed, but unpaved traffic surfaces to the full depth of the existing surfacing. The surfacing shall be stockpiled to the extent that it is acceptable and useable for restoration purposes.

B. Within Paved Areas:

1. The removal of pavement, sidewalks, driveways, or curb and gutter shall be performed in a neat and workmanlike manner. Concrete pavement, asphalt, sidewalks, driveways, or curb and gutter shall be cut with a power saw to a depth of two (2) inches prior to breaking. The concrete shall be cut vertically in straight lines and avoiding acute angles.
2. Bituminous pavement, sidewalks, driveways, or curb and gutter shall be cut with a power saw, pavement breaker, or other approved method of scoring the mat prior to breaking or excavation. The bituminous mat shall be cut vertically, in straight lines and avoiding acute angles.

3. Any overbreak, separation, or other damage to the existing bituminous or concrete outside the designated cut lines shall be replaced at CONTRACTOR's expense.

4. Excavated paving materials shall be removed from the job site and shall not be used as fill or backfill.

C. Excavate trenches to ensure that sides will be stable under all working conditions. Slope trench walls or provide supports in conformance with all local and national standards for safety. Open only as much trench as can be safely maintained by available equipment. Backfill all trenches as soon as practicable, but not later than the end of each working day.

D. Where trench walls are stable or supported, provide a width sufficient, but no greater than necessary, to ensure working room to properly and safely place and compact haunching and other embedment materials. The space between the pipe and trench wall must be wider than the compaction equipment used in the pipe zone. In addition to safety considerations, trench width in unsupported, unstable soils will depend on the size and stiffness of the pipe, stiffness of the embedment and in- situ soil, and depth of cover.

1. For PP, minimum trench width shall be not less than the greater of either the pipe outside diameter plus 16 in. or the pipe outside diameter times 1.25, plus 12 in. or in accordance with ASTM D2321.

2. For RCP, minimum clearance between pipe and trench wall shall be wide enough to ensure specified compaction of backfill material, but not less than outside diameter divided by 6 or in accordance with ASTM C1479.

E. Where trench walls or sub-grade are not stable or consist of unsuitable material, trench shall be widened as required in ASTM D2321 or ASTM C1479 as appropriate per material. Trench widths may be widened up to three diameters wide and subgrade increased to one half pipe diameter or as required by ENGINEER.

F. When supports such as trench sheeting, trench jacks, trench shields or boxes are used, ensure that support of the pipe and its embedment is maintained throughout installation. Ensure that sheeting is sufficiently tight to prevent washing out of the trench wall from behind the sheeting. Provide tight support of trench walls below viaducts, existing utilities, or other obstructions that restrict driving of sheeting.

3.3.2.2 Dewatering

A. All pipe trenches and excavation for structures and appurtenances shall be kept free of water during pipe laying and other related work. The method of dewatering shall provide for a dry foundation at the final grades of excavation in accordance with Section 31 23 19, Dewatering. Water shall be disposed of in a manner that does not inconvenience the public or result in a menace to public health. Pipe trenches shall contain enough backfill to prevent pipe flotation before dewatering is discontinued. Dewatering shall continue until such time as it is safe to allow the water to rise in the excavation.

B. Do not lay or embed pipe fittings or drainage structures in standing or running water. At all times prevent runoff and surface water from entering the trench.

C. When water is present in the work area, dewater to maintain stability of in-situ and imported materials. Maintain water level below pipe bedding and foundation to provide a stable trench bottom. Use, as appropriate, sump pumps, well points, deep wells, geotextile fabrics, perforated underdrains, or stone blankets of sufficient thickness to remove and control water in the trench. When excavating while depressing ground water, ensure the ground water is below the bottom of cut at all times to prevent washout from behind sheeting or sloughing of exposed trench walls. Maintain control of water in the trench before, during, and after pipe system installation and until embedment is installed and sufficient backfill has been placed to prevent flotation of the pipe, fitting, or drainage structures. To preclude loss of soil support, employ dewatering methods that minimize removal of fines and the creation of voids in in-situ materials.

3.3.2.3 Removal of Rock

A. Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between exposed rock and the pipe of at least six inches or as required by ENGINEER. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined under Section 31 00 00 Earthwork.

3.3.2.4 Removal of Unstable Material

A. Where wet or otherwise unstable soil incapable of properly supporting the pipe system, as determined by the Engineer, is encountered in the bottom of a trench, such material shall be removed to at least 24 inches below bottom of pipe and replaced to the proper grade with select granular material, compacted as directed by the ENGINEER. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Owner.

B. Where trench walls or sub-grade are not stable or consist of unsuitable material, trench shall be widened as required in ASTM D2321 or ASTM C1479 as appropriate per material. Trench widths may be widened up to three diameters wide and subgrade increased to one half pipe diameter or as required by ENGINEER.

3.3.3 Installation

A. General: Precautions shall be taken to prevent foreign material from entering the pipe before or while it is being placed in the line. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe. The open ends of pipe shall be closed with a plug, or with other devices approved by ENGINEER, at times when pipe laying is not in progress.

B. Pipe

1. Storm sewer pipe shall be installed in accordance with ASTM C1479 (RCP) or ASTM D2321 (PP), the manufacturer's recommendations for installing the type of pipe used, and what is shown on the DRAWINGS.

2. Pipe lines shall be laid to the grades and alignment shown on the DRAWINGS and as staked by ENGINEER. Variation from the prescribed grade and alignment shall not be allowed unless approved by ENGINEER.

3. RCP with lifting holes shall be installed such that the lifting holes are in the crown of the pipe. All lifting holes shall be properly grouted with non-shrink grout immediately after the pipe is installed and prior to commencement of backfilling. Lift hole grouting shall be inspected and approved by the ENGINEER immediately after the pipe is installed and prior to commencement of backfilling.

C. Pipe Fittings:

1. For RCP, fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations, and in a way that they meet or exceed performance standards found in ASTM C361, ASTM C443, or ASTM C1628.

2. For PP, fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations, and in a way that they meet or exceed performance standards found in ASTM F2764, ASTM F2881 or AASHTO M330.

3. Pipe fittings and appurtenances shall be carefully lowered into the trench with suitable tools or equipment to prevent damage to the pipe and protective coatings and linings; pipe and accessory materials shall not be dropped or dumped into the trench.

D. Gaskets: No gaskets that show signs of deterioration, such as surface cracking or checking, shall be installed in a pipe joint. Gaskets that sustain damage during the installation process shall be removed, discarded and replaced per the manufacturer's guidelines.

E. Obstructions not shown on the DRAWINGS may be encountered during the progress of the WORK. Should such an obstruction require an alteration to pipe alignment or grade, ENGINEER will have authority to order a deviation from the DRAWINGS, or ENGINEER may arrange for the removal, relocation, or reconstruction of any structure, which obstructs the pipeline.

3.3.4 Bedding

A. A stable and uniform bedding shall be provided for the pipe and any protruding features of its joint and/or fittings. The middle of the bedding, equal to one third of the pipe outside diameter, shall be loosely placed while the remainder shall be compacted to a minimum of 95% of maximum density per AASHTO T99, or as shown in the plans. Pipe bedding shall be a minimum of 4 - 6 inches in thickness.

B. The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe, and extend a minimum of 12 inches beyond the end of the pipe being laid.

3.3.5 Placing Pipe

A. Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Refer to Section 1.7 Delivery, Storage and Handling for pipe & fitting acceptance requirements.

B. Pipelines shall be laid to the grades and alignment indicated.

C. Proper facilities shall be provided for lowering sections of pipe into trenches.

D. Pipe shall not be laid in water, and the pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches shall be provided as directed by the engineer; see dewatering section.

E. Where outside diameter of bell exceeds outside diameter of pipe, care shall be taken to ensure adequate bedding material is moved to accommodate the difference of diameter and provide support to the entire joint and length of pipe.

3.3.6 Jointing

A. Joints shall be constructed as described herein and in accordance with manufacturer's installation instructions.

B. All Bell-and-Spigot pipe joints shall be thoroughly cleaned prior to joining.

C. Protective gasket wrap must be removed just prior to joint insertion to reduce the risk of introduction of foreign materials.

D. Joints with gaskets not pre-installed by the manufacturer must be clean and free of foreign materials prior to gasket installation.

E. Joint lubricant, supplied by the manufacturer, shall be applied to the interior of bell and the leading edge of the gasket on spigot prior to assembly.

F. Joints shall be assembled by inserting the spigot into the bell to prevent foreign materials from being trapped in the joint connection.

G. After initial assembly of the joint, CONTRACTOR shall verify line and grade of pipe. Prior to backfill and after final check of line and grade, the CONTRACTOR must verify the joint is fully inserted and properly sealed.

3.3.7 Backfilling

3.3.7.1 General

Backfill placement and compaction shall be constructed in accordance with the specifications herein and the product manufacturer's published installation guides

3.3.7.2 Backfilling Pipe in Trenches

A. Backfill shall be placed in accordance with ASTM D2321 (PP) and ASTM C1479 (RCP).

B. After the pipe has been laid on the bedding and is ready for backfill. Appropriate backfill at moisture content that will facilitate compaction, shall be placed in layers along both sides of the pipe at depths to ensure specified density is achieved evenly throughout the backfill material. Prior to compaction, backfill shall be placed under the haunches of the pipe.

C. Appropriate compaction methods shall be utilized in order to uniformly compact backfill to specified densities. Inappropriate or excessive compaction may damage the pipe and disturb line and grade.

D. Each layer shall be uniformly compacted with mechanical means. Backfill and compaction shall continue until fill has reached an elevation of at least 6 inches above the top of the pipe. The remainder of the trench shall be backfilled and compacted as noted on the plans or as directed by the ENGINEER.

E. Tests for density shall be made as directed by the ENGINEER to ensure conformance to the compaction requirements specified below.

F. Where it is necessary, in the opinion of the ENGINEER, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.3.7.3 Backfilling Pipe in Fill Sections

A. Select bedding and backfill material may be required and shall be so shown on the construction drawings.

B. For pipe placed in fill sections, fill shall be constructed to at least 6 inches above the top of proposed pipe prior to trench excavation. Bedding shall be distributed in six-inch (6") maximum layers over the full width of the trench and simultaneously on both sides of the pipe. Special care shall be taken to ensure full compaction under the haunches and joints of the pipe. Fill shall be placed in 12-inch lifts and shall be compacted to achieve 90% of maximum density, or as shown on plans. Once fill is placed and compacted pipe trench shall be constructed in accordance with 3.4.7.2 Backfilling Pipe in Trenches.

C. PP - Bedding and backfill materials shall conform to an ASTM D2321, unless approved in writing by the ENGINEER. Special attention shall be made to ensure based on an ASTM D2321 that fill over the pipe falls within the manufacturer’s and ENGINEER’s allowable limits.

D. RCP - Bedding and backfill shall conform to an ASTM C1479 Type I, II, or III installation, unless approved in writing by the ENGINEER. Special attention shall be made to ensure based on an ASTM C1479 Type I, II or III installation that fill over the pipe falls within the manufacturer’s and ENGINEER’s allowable limits.

3.3.7.4 Compaction

A. General Requirements

Non-cohesive materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, silts, and very fine sands. Non-cohesive soils consolidate best with vibratory compaction. Cohesive soils consolidate with equipment that kneads the soil in place. Backfill must be compacted with appropriate equipment to ensure the backfill uniformly consolidates to specified limits, without causing damage to or movement in the pipe during compaction operations.

B. Minimum Density

1. Backfill around pipe and structures shall be compacted at a +2.0% of optimum moisture content to densities listed below, or as directed by ENGINEER.

2. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 95 percent of standard proctor density for cohesive material and 90 percent of standard proctor density for non-cohesive material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

3. Under area without paved surfaces all soils shall be consolidated to a minimum 90 percent standard proctor density, unless specifically called out otherwise on the drawings.

3.3.7.5 Determination of Density

Testing shall be the responsibility of the CONTRACTOR and performed at no additional cost to the Owner. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval by the Engineer. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture density relations shall be made in accordance with ASTM D1557 except that mechanical tampers shall be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D2922. When ASTM D2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in the Calibration paragraph of the referenced publications. ASTM D2922 results in a wet unit weight of soil and when using this method ASTM D3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D3017 or ASTM D2922. Test results shall be furnished to the Engineer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed

3.3.7.6 Construction Equipment and Compaction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.4 TESTING AND INSPECTION

3.4.1 General

A. Following the placement and densification of backfill and prior to the placing of the permanent pavement, all pipes shall be cleaned, and inspected with CCTV; and certified as-built drawings shall be provided by the CONTRACTOR to the OWNER/ARCHITECT/ENGINEER.. Where damage or poorly installed pipe is observed the pipe shall be tested for leakage, have crack’s length and width quantified, joint gaps and offsets measured, and deflection verified; unless otherwise specified by the ENGINEER.

3.4.2 Television Inspection (CCTV)

A. A closed-circuit television (CCTV) inspection shall be conducted prior to new storm drain pipeline acceptance. The Inspection shall document and verify the following: The overall condition of the host pipeline, Line and Grade, Cleanliness, Joints, Cracks, and any other observed damage to the inside of the pipe.

B. The inspection will be used to evaluate issues that may affect long- term performance of the system. Evaluations on installed pipe shall be conducted per the AASHTO LRFD Bridge Construction Specification, Section 27 (RCP) and Section 30 (PP).

C. The inspection shall occur no sooner than 30-days after backfill reaches subgrade, unless approved by the ENGINEER.

D. The operator shall be trained and competent at operating equipment, taking accurate measurements, and identifying all items required to be noted in the inspection report.

E. Cleaning of the storm drains shall be performed prior to the television inspection.

F. The Contractor shall perform a television inspection (CCTV) on all storm drains between manholes and all storm drain inlet laterals at a speed no faster than 30 feet per minute using a Camera with high definition resolution, minimum one lux, 10x optical zoom, 10x digital zoom, and a lighting system that is sufficient to clearly illuminate a 60” diameter pipe 10 feet in front of the camera. Pipe runs shall be continuously measured from one pipe end to the other.

G. All joints shall be inspected with the camera stopping and rotating around the entire joint. The CCTV camera shall be centered in the pipe, have the ability to pan to a true 90 degrees from the pipe wall and rotate 360 degrees to fully view joints and any observed surface damage.

H. Joint separation greater than 0.5-inch, cracking greater than 0.01-inch, deflection over 5%, infiltration, or other noted damage inside the pipe may justify additional inspection, as directed by the ENGINEER.

I. The camera’s inspection systems shall be capable of accurately identifying the systems x, y, and z location in the pipe. Pipe length, diameter, location, location of noted items, photos of noted items, and a description of noted items shall all be documented and included in the inspection report. The system shall also have a GPS with sub meter accuracy so all manholes and other surface structures can be located and noted in the final report.

J. All data shall be provided digitally and provided in a final report to the OWNER, CONTRACTOR, and ENGINEER.

3.4.3 Tests for Deflection

A. When visual inspection or inspection by CCTV indicates a potential for excessive deflection, the following test method shall be used.

B. Deflection tests shall be made by the contractor upon completion and acceptance of backfill operations to finish subgrade, and prior to placement of the finished surface, if any. The deflection testing shall be witnessed by the Inspector and shall be conducted by the CONTRACTOR at the CONTRACTOR'S expense. Deflection shall be tested for excessive vertical deflection using a mandrel approved by the agency. The mandrel shall be sized so as to provide a diameter of at least 95% of the allowable minimum inside diameter. Elbow and wye type fittings should not have a mandrel pulled through them.

C. Pipe 36" or larger may be direct measured provided the appropriate safety equipment and certifications are use and held by the inspectors.

D. Laser profiling equipment may be used instead of pulling mandrels. All laser profiled results are subject to verification by mandrel or direct measurement.

3.4.4 Measuring Cracks and Open Joints

A. For RCP, joints separated by more than 0.5-inch and cracks wider than 0.01-inch shall be accurately measured and noted in the inspection report. If camera optics and on-board measuring device is not capable of accurately measuring down to 0.01" then the system shall not be used, unless approved by the ENGINEER.

B. For PP, joints separated by more than the manufacturers' allowable tolerance shall be accurately measured and noted in the inspection report and repaired by the CONTRACTOR as directed by the manufacturer. If camera optics and on-board measuring device is not capable of accurately measuring down to 0.01" then the system shall not be used, unless approved by the ENGINEER.

C. Pipe 36" and larger may have joints and cracks directly measured using a tape measure for joints gaps and crack lengths, and a feeler gauge for crack widths. Photos of damage should be taken, with locations of each measurement located relative to the pipe ends

END OF SECTION