PROJECT MANUAL

D.P. CULP EXPANSION & RENOVATION
FOR
EAST TENNESSEE STATE UNIVERSITY

RELEASE PACKAGE 2
MAIN BUILDING SET

SBC Project No. 166/005-01-2014CM

PREPARED FOR:
OWNER

TENNESSEE BOARD of REGENTS
Office of Facilities Development
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Nashville, Tennessee 37214

PREPARED BY:
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ARCHITECT of RECORD / CIVIL ENGINEERING

and

CONSULTANTS / ENGINEERS:

XCELERATED CONCEPTS, LLC
FOODSERVICE

RBA STRUCTURAL ENGINEERING, LLC
STRUCTURAL ENGINEERING

FACILITIES SYSTEMS CONSULTANTS, LLC.
MECHANICAL, PLUMBING & ELECTRICAL ENGINEERING

ROSS/FOWLER LANDSCAPE ARCHITECTURE URBAN DESIGN & PLANNING
LANDSCAPE ARCHITECT

CONSTRUCTION DOCUMENTS

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March 1, 2018
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### DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT

No work proposed or sections required for this Contract

### END OF SECTION
SECTION 21 10 00

FIRE PROTECTION

PART 1  GENERAL

1.01  PROJECT SUMMARY

A. Work in this Section includes, but is not necessarily limited to providing all engineering and associated costs, calculations, labor, materials, supervision, testing, permits and approvals required to design, install and obtain final acceptance of the automatic fire protection sprinkler system complete in all respects.

B. The fire protection system shall provide full and complete coverage of all areas, and shall be compatible with the contract document layouts and avoid interference with work of all other trades in the building. Contractor shall provide offsets as needed to avoid other trades, including but not limited to mechanical ductwork, hydronic piping, structural elements and lighting.

C. Provide fire protection system complete with all component equipment and material items. Install and test in full conformity with the requirements of all applicable codes, National Fire Protection Association (NFPA) 13-2012 Edition.

1.02  DEFINITIONS

A. Working Plans: Documents, including shop drawings, calculations, and material specifications prepared according to NFPA 13, 14, and 24 for obtaining approval from authorities having jurisdiction.

1.03  SYSTEM PERFORMANCE REQUIREMENTS

A. Sprinkler systems shall not be calculated to less than 5 psi or 10% below the actual water supply available, whichever is greater. Sprinkler plans and calculations must take into account and show elevation loss from the flow test location to the flowing sprinklers. Flow test information must be recent to within one (1) year previous to submittal of sprinkler drawings.

B. NFPA standards require that the spray deflector of the sprinkler heads be installed eighteen (18") inches minimum above the top of the shelves.

C. Sprinkler deflectors shall be positioned to avoid obstruction to both activation and discharge. Obstructions are (but are not limited to) lights, diffusers, duct-work, structural members (false or real), displayed signage or any object capable of impeding the proper activation and discharge of the fire sprinklers. Installation shall comply to the referenced NFPA 13 document (Chapter 4) and the manufacturers listing. The sprinkler contractor shall be responsible for final coordination.
D. All obstructions exceeding four (4') feet wide or which cannot be spaced around (to comply with 1.4.F) shall have sprinklers installed beneath the obstruction. If sprinklers are installed at or below 7’.6" they shall be equipped with a listed head guard.

E. All sprinkler heads in finished ceilings shall be symmetrically spaced to provide proper coverage, and to avoid interference with lights, diffusers, grilles, or other ceiling mounted equipment. The head layout shall conform to the typical pattern and centered in any ceiling tile or similar feature.

F. All overhead piping located in areas containing ceilings shall run concealed above the ceiling, without exception.

G. Consult the bid specification drawings for acceptable locations for all piping to be run exposed (areas without ceilings).

H. Inspector's tests to be provided with half-inch orifice, discharging at three (3") inches above a hard paved surface. Provide pressure relief valves at inspectors test locations on all "grid" type systems. All inspector's test shall not be located behind racking or other obstructions, and shall be located within eighteen (18") inches of an exterior door opening.

I. Provide flushing and drainage as per required in NFPA 13.

J. System control valves accessed from the interior of the riser area and shall be tampered butterfly valves.

K. Provide sprinkler protection at electrical rooms per the requirements of the local jurisdiction.

L. The calculations shall include all sprinklers within the most hydraulically demanding area along each branch line within the distance determined using a 1.2 multiplier (times the square feet of the area).

M. The contractor shall provide a valve connection discharging onto a paved (outside) surface, to allow full system demand to flow forward of the backflow preventor for testing. The test connection shall be capable of full system flow and shall not require system drainage or alteration. Note, the two (2") inch main drain and FDC are not acceptable.

**PART 2 PRODUCTS**

2.01 GENERAL PARAMETERS

A. All materials submitted and installed shall be UL listed, individually or as any assembly to be installed in a fire protection system.

B. All materials shall be acceptable to all national and local applicable codes and standards.
2.02 SPRINKLER HEADS

A. No sprinklers to be installed are permitted to have a rubber O-ring seal. Only metallic "spring seal" or equivalent seals are allowed.

B. All sprinkler types and temperature ratings shall be as indicated on the drawings.

2.03 BRACKETS

A. Brackets for attaching pipe hangers to building structure shall be the size and type for the intended use, and acceptable to the structural engineer in accordance with NFPA 13.

2.04 SWITCHES

A. Provide all tamper and flow switches for indicating control valves and systems and as required by local ordinances.

2.05 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. Specialty Valves and Devices:
   a. Grinnell Corp.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Viking Corp.

2. Water-Flow Indicators and Supervisory Switches:
   a. Grinnell Corp.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Viking Corp.

3. Sprinkler, Drain and Alarm Test Fittings:
   a. Central Sprinkler Corp.
   b. Grinnell Corp.
   c. Victaulic Co. of America

4. Sprinkler, Branch-line Test Fittings:
   b. Fire-End and Croker Corp.

5. Sprinkler, Inspector's Test Fittings:
   a. Fire-End and Croker Corp.
   b. G/J Innovations, Inc.
   c. Triple R. Specialty of Ajax, Inc.

6. Fire Department Connections:
   a. Grinnell Corp.
   b. Guardian Fire Equipment, Inc.
c. Reliable Automatic Sprinkler Co., Inc.

7. Sprinklers:
   a. Grinnell Corp.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Viking Corp.

8. Indicator Posts and Indicator-Post, Gate Valves:
   b. Grinnell Corp.
   c. Nibco, Inc.

9. Indicator Valves:
   a. Grinnell Corp.
   b. Nibco, Inc.
   c. Victaulic Co. of America

10. Fire Protection-Service Valves:
   a. Grinnell Corp.
   b. Nibco, Inc.
   c. Victaulic Co., of America

11. Grooved Couplings for Steel Pipe
   a. Grinnell Corp.
   b. National Fittings, Inc.
   c. Victaulic Co. of America

2.06 PIPE AND FITTINGS

A. Ductile-Iron Pipe: AWWA C151, push-on-joint type, with cement-mortar lining and seal coat according to AWWA C104. Include rubber gasket according to AWWA C111.

B. Ductile-Iron Pipe: AWWA C151, mechanical-joint type; with cement-mortar lining and seal coat according to AWWA C104. Include glad, rubber according to NFPA 1963 and matching local fire department sizes and threads, and bottom outlet with pipe threads. Include brass, lugged caps, gaskets, and brass chains; brass, lugged swivel connection and drop clapper for each hose-connection inlet; eighteen (18") inch (460-mm) high brass sleeve; and round, floor, brass, escutcheon plate with marking "AUTO SPKR."
   2. Finish Including Sleeve: Rough chrome-plated.

C. Other Pipe: ASTM A795, Sch 40 Steel Pipe (or Sch 10 where allowed by NFPA 13).

2.07 PRESSURE GAUGES

A. Pressure Gauges: UL 393, 3 ½ to 4 ½ inch - )90 to 115 mm) diameter dial with dial range of 0 to 300 psig.
PART 3  EXECUTION

3.01  INSTALLATION

A. Furnish and install under this Section all hangers and steel fabrications, other than building structure, required for proper support of piping and equipment.

3.02  IDENTIFICATION

A. Identify exposed or accessible piping with snap-on or strap-on type markers. Color or markers shall be red for all fire protection service. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels and at least once above each space.

3.03  HANGER ATTACHMENTS

A. Support of pipes with diameter larger than 2 ½ inches may require modification of structural members to support increased loads. Suspend piping and equipment supported by building structure only by those methods, and only at those locations acceptable to the structural engineer.

B. Provide supplementary supporting steel fabrication to bridge between structural steel fabrication to bridge between structural members to receive the hanger. Attach supplementary members to building structure only by those methods, and at those locations acceptable to the structural engineer.

3.04  INSPECTION, TESTING, AND CLEANING

A. Arrange for all inspections, examinations and tests in full conformity with the requirements of all applicable codes, National Fire Protection Association (NFPA) standards and authority having jurisdiction necessary to obtain complete and final acceptance of the fire sprinkler system.

B. Flush underground piping and pressure test at 200 psi for two (2) hours prior to connection to overhead piping. Flushing and testing shall be witnessed by the Fire Department.

C. Leave entire sprinkler system clean in every respect at the conclusion of the work.

D. Testing will occur after installation of all systems has been completed (approximately two (2) to three (3) weeks prior to opening). The contractor shall be required to provide a lift, air, and water pumps for system pressurization, and any necessary hand tools and apparatus for complete testing and draining of the systems. One (1) test of all systems should be completed within one (1) day. If all or any systems fail, the contractor shall be responsible to be present and furnish all items listed
above until such time that systems are found to be acceptable or in accordance with NFPA 13, 25, and the bid documents. The contractor is responsible for notifying the Owner when installation is complete and testing may begin. Please allow five (5) to ten (10) working days for scheduling.

E. The contractor shall furnish to the owner a complete set of signed and witnessed test certificates for the following:
   1. Underground flushing.
   2. Underground hydrostatic test.
   3. Interior wet system hydrostatic test(s).
   4. All system trip tests.

F. The Contractor shall train owner on use of all equipment and furnish two (2) copies to be left on site, of NFPA 25 the latest edition, and all apparatus manuals, please allow seven (7) days for scheduling.

3.05 WARRANTY

A. Provide warranty in accordance with the General Conditions for a period of at least one (1) year.

   END OF SECTION
GENERAL PROVISION FOR PLUMBING

PART 1  GENERAL

1.01 QUALITY ASSURANCE

A. Conform to the following:
   1. International Plumbing Code – 2012

1.02 STANDARDS

A. Comply with all pertinent standards.
   1. AWS: American Welding Society.
   2. ASME: American Society for Mechanical Engineers.
   3. MSS: Manufacturer's Standard Society.

1.03 SUBMITTALS

A. Submit under provisions of Division 01.
   1. Submit complete descriptions, specification data for material and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet.
   2. Submittals in 3-ring binders shall include an index of contents and divider tabs.
   3. Shop Drawings:
      a. Plumbing Fixtures and Hardware
      b. Piping Systems
      c. Valves
      d. Insulation
      e. Pumps
      f. Water Heaters
      g. Plumbing Specialties

1.04 REGULATORY REQUIREMENTS

A. Perform Work specified in Division 22 in accordance with 2012 IPC and by the authority having jurisdiction.

1.05 PROJECT/SITE CONDITIONS

A. Layouts indicated on drawings are diagrammatical and intended to show relative positions and arrangement of equipment and piping. Coordinate plumbing work with other trades and measurements obtained at the job site, as applicable, prior to installation. Generally, install work in locations shown on Drawings, using as necessary, rises, drops, offsets, and alternate routings to fit in the available space unless prevented by Project
1.06 COMPLETENESS OF WORK

A. The Contract Documents depict plumbing systems which are intended to be complete and functioning systems. All products, materials, and labor necessary to render a fully functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.

B. Model numbers referenced throughout the Division 22 Drawings and Specifications are intended to convey a general understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a model number, the written description shall govern. No extra shall be allowed because a model number is found to be incomplete or obsolete.

1.07 RECORD DRAWINGS

A. Provide record drawings that illustrate the work of Division 22 as finally constructed. Provide dimensions of material installed below slab/grade from fixed and visible reference points. Deliver record drawings to the architect in a form suitable for production.

B. Record drawings shall reflect all changes made to the Contract Documents, whether generated by addenda, change orders, or field conditions. Maintain a daily record of these changes and keep current set of drawings showing these changes.

C. Deliver record drawings to Architect within 30 days of Substantial Completion.

1.08 OWNER AND OPERATING MANUALS

A. Comply with the requirements of Division 01, but provide a minimum of three sets, in three ring binders, all sets identical.

B. Manuals shall include clear and comprehensive operating instructions with appropriate graphics and project specific marked data to enable owner to operate and maintain all systems specified in this Division.

C. Copies of approved submittals on furnished equipment shall be included.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.01 EXCAVATING AND BACKFILLING

A. Provide trenching, excavating, and backfilling necessary for performance of plumbing work in accordance with Division 02.
3.02 CUTTING AND PATCHING

A. Repair or replace damage caused by cutting or installation of work specified in Division 22.

B. Perform repairs with materials which match existing and install in accordance with the appropriate section of these specifications.

C. Correct unnecessary damage caused due to the installation of plumbing work.

3.03 FLASHING AND COUNTERFLASHING

A. Counterflash pipes where penetration of roofs and outside walls occur.

3.04 DELIVERY, STORAGE, AND PROTECTION

A. Insofar as possible, deliver items in manufacturer’s original unopened packaging. Where deliver in original packaging is not practical, provide cover and shielding for all items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storing to keep items from being damaged.

B. Store items in a clean, dry place, and protect from damage. Mechanical equipment may not be staged or stored outdoors unless intended for outdoor use. Do not install damaged or wet insulation; Remove from site.

C. Protect nameplates on motors, pumps, and similar equipment. Do not paint or insulate over nameplate data.

D. Protect valves and piping from damage. Cover equipment during work of finishing trades.

E. Keep dirt and debris out of pipes.

F. Repair, restore, and replace damaged items.

G. Cover factory finished equipment during work of finished trades, such plumbing fixtures and water heaters.

3.05 SLEEVES

A. Floors: Sleeve all pipe penetrations. Extend sleeve 1-1/2" above finished floor, except piping within pipe chases. Sleeve shall be flush with underside of floor.

B. Masonry or concrete walls: Sleeve all pipe penetrations. Sleeves shall be flush on both sides of wall.
C. Drywall partitions: Sleeve all penetration of piping in systems over 160 degree F.

D. Seal voids between outside surface of sleeve and wall, partition or floor. Seals shall be airtight.

E. Install piping, insulation and sleeves in strict accordance with applicable U.L. floor or partition assembly instructions. Coordinate with Division 07 firestop manufacturer's installation instructions.

F. Penetrations not sleeved or firestopped:
   1. Seal voids between pipe and partition. Seals shall be airtight.

3.06 ESCUTCHEON PLATES

A. Provide chromium plates escutcheon plates for exposed uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electric closets, and janitor closets are not considered "finished" spaces.

B. Clearance between sleeve and pipe: Minimum of 1/2 inch for hot piping and 1 inch for cold piping or as otherwise dictated by U.L. Fire Resistance Directory.

3.07 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

C. Test hot and cold domestic water piping systems upon completion of rough-in and before connection to fixtures at a water pressure of 125 psig for two hours without leaks.

D. Test drainage and venting system with necessary openings plugged to permit system to be filled with water and subjected to a minimum water pressure of 10 feet head at top of system. System to hold water for two hours without a water level drop greater than 4" in a 4" standpipe and without visible leakage. Test system in sections if minimum head can be maintained in each section.

E. Conduct air or smoke test if in opinion of Designer reasonable cause exists to suspect leakage or low quality workmanship.

F. Test flush valves for proper operation.

END OF SECTION
SECTION 22 05 53

IDENTIFICATION OF PLUMBING PIPING AND EQUIPMENT

PART 1  GENERAL (NOT USED)

PART 2  PRODUCTS

2.01  NAMEPLATES AND TAGS

A.  Acceptable manufacturers: Seton Nameplate or Brady.

B.  Rigid plastic, "Setonite" or bakelite with engraved lettering, minimum 1/2" high.

C.  Brass tags, at least 1-1/2" inches in diameter, with alpha-numeric I.D., permanently stamped black filled letters showing the service, and black filled numbers showing the equipment number. At substantial completion, a schedule of all valves shall be submitted to the Architect and Owner's Representative.

2.02  PIPE MARKERS

A.  Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, pre-formed to fit around pipe or pipe covering.

2.03  PIPE IDENTIFICATION

A.  Pipe Identification:
   1.  Identify piping by snap-on or strap-on labels (to denote contents and direction of flow) on piping at no more than 20 foot intervals at valves, and at least once in each separate space through which the pipe passes.
   2.  Identification includes domestic cold water; hot water; recirculation hot water; rainwater; storm; waste; gas.
   3.  All piping in mechanical rooms shall be labeled to identify contents and direction of flow.

2.04  EQUIPMENT AND APPARATUS IDENTIFICATION

A.  Acceptable Manufacturers: Seton Name Plate Corporation or equal.

B.  Nameplates: Rigid plastic, "Setonite", Seton or Brady with engraved lettering (indicating names and numbers of mechanical apparatus), a minimum of 1/2" high. Fill engraved lettering with a permanent coloring material which contrasts with color of tag material to allow for easy reading.

C.  Use names, numbers, and abbreviations appearing in schedules on Contract Drawings.
D. Provide nameplates, located in a conspicuous location directly on the equipment or apparatus, for mechanical equipment including, but not limited to:
   1. Water heaters
   2. Pumps
   3. Plumbing equipment

E. Name tag Fasteners: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws, or rivets. If equipment surface does not allow for direct attachment, use copper or brass rings to attach tags.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pipe identification markers per manufacturer's installation instructions.

B. Install equipment nameplates per manufacturer's installation instructions.

END OF SECTION
SECTION 22 07 19

PLUMBING INSULATION

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 method.

1.02 EXISTING SERVICES

A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

Johns Manville Corp.
Owens-Corning Fiberglas Corp.
Rubatex Corp.

2.02 PIPING INSULATION MATERIALS:

A. Fiberglass Piping Insulation: ASTM C 547, Type I unless otherwise indicated.

B. Flexible Unicellular Piping Insulation: ASTM C 534, Type I (Tubular).

C. Jackets for Piping Insulation: ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installer's option.

   1. Encase pipe fittings, valves, strainers, etc. with insulation with glass fabric and vapor barrier mastic applied as per manufacturer's recommendations.

D. Encase the following with 0.016" smooth aluminum jacket, secured with sheet metal screws and 1/4-inch aluminum bands. Fittings shall be covered with factory-formed aluminum elbow covers.

   1. All interior piping insulation within 7'-0" of floors or work surfaces.
   2. All valves, fittings, etc. within 7'-0" of floors or work surfaces.
   3. All fittings within 7'-0" of floors or work surfaces to be covered with factory formed aluminum elbow covers.
E. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

F. Tees and elbows for insulated piping shall be factory premolded insulation fittings, similar to that manufactured by Hamfab.

G. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

2.03 EQUIPMENT INSULATION MATERIALS:

A. Flexible Unicellular Equipment Insulation: ASTM C 534, Type II.

B. Jacketing Material for Equipment Insulation: Provide metal jacket, except as otherwise indicated.

C. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

D. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

PART 3 EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 PLUMBING PIPING SYSTEM INSULATION:

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, strainers, check valves, balance cocks, flow regulators, drain lines from water coolers, and pre-insulated equipment.

B. Cold Piping:
   1. Application Requirements: Insulate all cold plumbing piping systems, which include the following:
      a. Potable cold water piping.
      b. Horizontal interior above-ground storm and rain water piping.
      c. Condensate piping.
   2. Insulate each piping system specified above with one of the following types and thicknesses of insulation with a thermal conductivity of 0.24 to 0.28 BTU · in/(h · ft 2 · 0F):
      a. Fiberglass: 1/2" thickness for cold water.
      b. Fiberglass: 1" thickness for storm rain water.
      c. Fiberglass: 1/2" thickness for condensate piping.
C. Hot Piping:
   1. Application Requirements: Insulate all hot plumbing piping systems, which include the following:
      a. Potable hot water piping.
      b. Potable hot water recirculating piping.
   2. Insulate each piping system specified above with one of the following types and thicknesses of insulation with a thermal conductivity of 0.24 to 0.28 BTU ·in/(h · ft 2 · °F):
      a. Fiberglass: 1" thick for potable hot water supply.
      b. Fiberglass: 1" thick for recirculating hot water piping.

D. Glass fiber blanket inserts with PVC covers are not acceptable for pipe fitting insulation.

E. Hangers:
   1. All hanger nuts to be tighten AFTER insulation is added to the piping.
   2. All metal shields should be installed BEFORE nuts are tightened. Minimum shield length shall be 12". Provide a section of Foamglass insulation between pipe and metal shield to prevent crushing of insulation. All shields shall be 14 gauge.

F. Protection
   1. All damaged insulation caused by maintenance or construction shall be replaced by contractor, up to and through the completion of the Punch List.

3.03 INSTALLATION OF PIPING INSULATION:

A. Use glass fiber sectional pipe insulation for domestic water piping. Glass fiber factory premolded fitting matching basic insulation equivalent to that manufactured by Hamfab shall be provided at all pipe fittings (Tees and ells) and finished with glass fabric and vapor barrier mastic. Glass fiber blanket inserts with PVC covers are not acceptable for pipe fitting insulation.

B. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

C. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

D. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

E. Clean and dry pipe surfaces prior to insulating. All butt-joints for cold water or condensate drain lines must be glued securely any openings to prevent the build-up of condensation.

F. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Repair any insulation jacket damaged so
it has permanent seal. Cover all joints, rips, tears punctures, staples, insulpins or breaks in vapor barrier jacket with 4" wide woven glass fabric embedded in vapor barrier fire resistant mastic.

G. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

I. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band. Piping insulation to continue through 100% of pipe hangers. No insulation shall be cut where a hanger is located for any loop water, cold water or condensate drain lines.

J. Insulate all domestic water valves that could condensate and drip.

K. For any service when above grade, exposed to weather outside building, and exposed in equipment rooms to within 7 feet above floors, cover pipe insulation with 0.016" thick smooth aluminum jacket equivalent to Childers and cover valves and fittings with .024" thick aluminum factory formed covers equivalent to Childers E11-Jacs.

3.04 INSTALLATION OF EQUIPMENT INSULATION:

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Apply insulation using staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

E. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

F. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

G. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
H. Hangers:
   1. All hanger nuts to be tighten AFTER insulation is added to the equipment
   2. All metal shields to be installed BEFORE nuts are tightened.

I. Protection
   1. If equipment will be walked on to do further maintenance or construction work then the insulation will be replaced by contractor, up to and through the completion of the punch list.
   2. If equipment that is insulated may need to be walked on for the long-term maintenance of the building, proper shields will be provided at traffic ways that cross the piping.

3.05 PROTECTION AND REPLACEMENT:
   A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
   B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION
SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1   GENERAL

1.01   RELATED DOCUMENTS

   A. Drawings and general provisions of the Contract, including General and
      Supplementary Conditions and Division 1 Specification Sections, apply to this
      Section.
   
   B. Section 019113 – General Commissioning Requirements
   
   C. Section 230800 – Commissioning of HVAC
   
   D. Section 260800 – Commissioning of Electrical Systems
   
   E. Commissioning Plan, dated [TBD]

1.02   COMMISSIONED SYSTEMS

   A. Commissioning is an ongoing process and shall be performed throughout
      construction. Commissioning verifies that systems are operating in a manner
      consistent with the Contract Documents.
   
   B. Following is a detailed list of equipment included in each commissioning activity:
      
      1. Domestic Hot Water Circulating Pumps
      2. Domestic Hot Water Heaters
      3. Mixing Valves
      4. Sump Pumps

1.03   RESPONSIBILITIES

   A. The Contractor shall be responsible for scheduling, supervising and performing
      start-up, testing and commissioning activities specified in this section and
      necessary to demonstrate to the Owner successful operation of the
      commissioned systems.

PART 2   PRODUCTS

2.01   MEANS OF ACCESS

   A. The Contractor shall provide means for the CxA to access, observe and visually
      confirm proper operation of all equipment and systems. These means shall be in
      compliance with all OSHA and job-site safety regulations.
2.02 TEST EQUIPMENT

A. The Contractor shall provide the necessary equipment to fully test the commissioned systems as defined in the functional performance test procedures to be provided by the CxA.

PART 3 EXECUTION

3.01 EQUIPMENT CHECKLISTS

A. Equipment checklists, provided by the CxA, shall be completed by the Contractor on CxAlloy. The following checklists shall be provided:

1. Equipment Pre-Functional Checklist

3.02 FUNCTIONAL PERFORMANCE TESTS

A. The Contractor shall provide all documentation as requested to the CxA for development of functional performance testing procedures. This documentation shall include, at a minimum, manufacturer installation, start-up, operation and maintenance procedures. The CxA may request further documentation as necessary for the development of functional performance tests.

B. The Contractor shall review the functional performance test procedures developed by the CxA.

1. The Contractor shall respond in writing to the CxA regarding the acceptability of the proposed test procedures.

2. The Contractor shall note any necessary modifications to the procedures due to the actual equipment/systems or safety concerns and shall submit these to the CxA for consideration.

C. The Contractor shall place equipment and systems into operation and continue the operation as required during each working day of the testing activities.

D. The Contractor shall accomplish the functional performance testing of equipment based on procedures developed by the CxA and as reviewed by the Contractor.

1. The Contractor shall provide skilled technicians to operate the systems during functional performance testing. At a minimum, the contractor should provide one trade technician familiar with the system being tested and one controls technician to operate the system through the BAS.

2. The Contractor shall correct any deficiencies identified during testing and retest equipment as required.

E. Functional performance testing is intended to begin upon completion of a system. Functional performance testing may proceed prior to the completion of the system at the discretion of the CxA and the Contractor.
F. Functional testing shall verify all sequences of operation defined in the Contract Documents for the commissioned equipment and systems.

1. Testing shall occur by overriding setpoints or sensor readings at the BAS or by other means mutually agreed to by the Contractor, the CxA, and the Owner to initiate sequences of operation and verifying the response of the system.

2. Sequences of operation shall be verified under normal power, emergency power, and fire alarm scenarios.

G. Upon successful completion of all functional performance tests, the Contractor(s) shall perform Integrated Systems Testing. The testing shall document and verify the proper response of all Division 22 systems to all potential utility and emergency power operating and failure scenarios.

END OF SECTION
SECTION 22 10 05

PLUMBING PIPING & VALVES

PART 1  GENERAL

1.01  REFERENCES

A. Submit pipes, valves and fittings and have approval prior to starting construction. Pipe, valves and fittings shall be new and clearly marked with manufacturer’s name, classification and working pressure.

PART 2  PRODUCTS

2.01  SANITARY SEWER PIPING, BURIED

A. PVC Pipe: ASTM D 2665 or ASTM D 3034.
   1. Fittings: PVC.

2.02  SANITARY SEWER AND CONDENSATE PIPING, ABOVE GRADE

A. Sanitary Sewer - Cast Iron Pipe: CISPI 301, hubless service weight.
   1. Fittings: DWV Cast Iron.

B. Condensate Piping - Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), Drawn (H).
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.

2.03  WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Copper Pipe: ASTM B 42, hard drawn.
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.

2.04  WATER PIPING, ABOVE GRADE

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), Drawn (H).
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.

2.05  FLANGES, UNIONS, AND COUPLINGS

A. Unions for Pipe Sizes 3 Inches and Under:
   1. Ferrous pipe: Class 150 malleable iron threaded unions.
2. Copper tube and pipe: Class 150 bronze unions with soldered joints.

B. Flanges for Pipe Size Over 1 Inch:
   1. Ferrous pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
   2. Copper tube and pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.06 PIPE HANGERS AND SUPPORTS

A. Plumbing Piping - Drain, Waste, and Vent:
   2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Carbon steel, adjustable swivel, split ring.
   3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
   8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

B. Plumbing Piping - Water:
   2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Carbon steel, adjustable swivel, split ring.
   3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
   5. Multiple or Trapeze Hangers: Steel channels with welded supports or spacers and hanger rods.
   7. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

2.07 BALL VALVES

A. Construction, under 2 Inches: MSS SP-110, Class 150, 400 psi CWP, bronze, two piece body, stainless steel brass ball, full port, teflon seats and stuffing box ring, blow-out proof stem, lever handle, threaded ends with union. Nibco TS 585 or approved equal.
2.08 AIR VENTING
A. Provide manually operated air vents at high points in vertical risers to eliminate air from systems.
B. Use ball valves for manual air vents.

2.09 ESCUTCHEONS
A. Provide chrome plated escutcheons where insulated pipes penetrate walls or ceilings of finished spaces.

PART 3 EXECUTION

3.01 EXAMINATION
A. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION
A. Ream pipe and tube ends. Remove burrs.
B. Remove scale and dirt, on inside and outside, before assembly.
C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION
A. 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. Install piping free of sags and bends. Group piping whenever practical at common elevations.
B. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
C. Do not use bullhead tees.
D. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
E. Install fittings for changes in direction and branch connections.
F. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
G. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

J. Provide access where valves and fittings are not exposed. Install piping to permit servicing.

K. Install vent piping penetrating roofed areas to maintain integrity of roof assembly.

L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

M. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.

N. Install bell and spigot pipe with bell end upstream.

O. Install valves with stems upright or horizontal, not inverted.

P. Install water piping to ASME B31.9.

3.04 SLEEVES AND INSERT

A. Sleeve pipes passing through partitions, walls and floors.

B. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
   4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.05 PIPE HANGERS AND SUPPORTS:

A. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9.
   2. Support horizontal piping as scheduled.
   3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.
   5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Provide copper plated hangers and supports for copper piping.
9. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
10. Provide hangers adjacent to motor driven equipment with vibration isolation.

3.06 APPLICATION
A. Install unions downstream of valves and at equipment or apparatus connections.
B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
C. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

3.07 ERECTION TOLERANCES
A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/8 inch per foot slope.
B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

3.08 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM
A. Disinfect water distribution system.
B. Prior to starting work, verify system is complete, flushed and clean.
C. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
E. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
F. Maintain disinfectant in system for 24 hours.
G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
H. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
I. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.09 SCHEDULES

A. Pipe Hanger Spacing:
   1. Metal Piping:
      a. Pipe size: 1/2 inches to 1-1/4 inches:
         1) Maximum hanger spacing: 6.5 ft.
         2) Hanger rod diameter: 3/8 inches.
      b. Pipe size: 1-1/2 inches to 2 inches:
         1) Maximum hanger spacing: 10 ft.
         2) Hanger rod diameter: 3/8 inch.
      c. Pipe size: 2-1/2 inches to 3 inches:
         1) Maximum hanger spacing: 10 ft.
         2) Hanger rod diameter: 1/2 inch.
      d. Pipe size: 3 inches to 4 inches:
         1) Maximum hanger spacing: 12 ft.
         2) Hanger rod diameter: 1/2 inch.

END OF SECTION
SECTION 22 10 06

PLUMBING PIPING SPECIALTIES

PART 1  GENERAL (NOT USED)

PART 2  PRODUCTS

2.01 WATER HAMMER ARRESTORS

A. Water Hammer Arrestors:
   1. Copper construction, bellows type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range 34 to 250 degrees F (1 to 120 degrees C) and maximum 150 psi (1000 kPa) working pressure.

2.02 MIXING VALVES

A. Thermostatic Mixing Valves:
   1. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
   2. Accessories:
      a. Check valve on inlets.
      b. Volume control shut-off valve on outlet.
      c. Stem thermometer on outlet.
      d. Strainer stop checks on inlets.
   3. Cabinet: 16 gage enameled steel, for surface mounting with keyed lock.

2.03 BALANCING VALVES

A. Memory-Stop Balancing Valves
   2. Pressure Rating: 400-psig minimum CWP.
   3. Size: NPS 2 or smaller.
   4. Body: Copper alloy.
   5. Port: Standard or full port.
   7. Seats and Seals: Replaceable.
   8. End Connections: Solder joint or threaded.

2.04 WALL HYDRANTS

A. Nonfreeze Wall Hydrants
   3. Operation: Loose key.
   4. Casing and Operating Rod: Of length required to match wall
thickness. Include wall clamp.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Chrome plated.
11. Operating Key(s): One with each wall hydrant.

2.05 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device
4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.06 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves
2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.8 CLEANOUTS

A. Cleanouts at Exterior Surfaced Areas
1. Round cast nickel bronze access frame and non-skid cover.

B. Cleanouts at Exterior Unsurfaced Areas
1. Line type with lacquered cast iron body and round epoxy coated gasketed cover.

C. Cleanouts at Interior Finished Floor Areas
1. Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept
floor finish in finished floor areas.

D. Cleanouts at Interior Finished Wall Areas
   1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.

E. Cleanouts at Interior Unfinished Accessible Areas Caulked or threaded type.
   1. Provide bolted stack cleanouts on vertical rainwater leaders.

**PART 3  EXECUTION**

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

C. Encase exterior cleanouts in concrete flush with grade.

D. Install floor cleanouts at elevation to accommodate finished floor.

E. Install approved potable water protection devices on plumbing lines where contamination of domestic water may occur; on boiler feed water lines, janitor rooms, premise isolation, irrigation systems, flush valves, interior and exterior hose bibs.

F. Pipe relief through fixed airgap and discharge to sewer.

G. Install water hammer arrestors complete with accessible isolation valve on hot and cold water risers and supply piping to lavatories.

H. Install supply type, trap-seal primer valves with outlet piping pitches down toward drain trap at a minimum of 1 percent, and connect to floor drain body, trap or inlet fitting. Adjust valve for proper flow.

**END OF SECTION**
SECTION 23 05 00

GENERAL PROVISION FOR HVAC

PART 1  GENERAL

1.01 QUALITY ASSURANCE

A. Conform to the following:
   2. International Mechanical Code – 2012

1.02 STANDARDS

A. Comply with all pertinent standards.
   1. AMCA: Air Moving and Conditioning Association
   3. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.
   4. ASME: American Society for Mechanical Engineers.
   5. NEMA: National Electrical Manufacturer's Association.
   7. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
   8. UL: Underwriters' Laboratories, Inc.

1.03 SUBMITTALS

A. Submit under provisions of Division 01.
   1. Submit complete descriptions, specification data for material and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet.
   2. Submittals in 3-ring binders shall include an index of contents and divider tabs.
   3. Shop Drawings:
      a. Control System
      b. Air Handling Equipment
      c. Air Terminal Units
      d. Fan Coil Units
      e. Air Distribution, Ductwork, Grilles, Registers
      f. Insulation
      g. Filters
      h. Vibration Isolation
      i. Boilers
      j. Chillers
      k. Pumps and Hydronic Specialties
      l. Sound attenuators
      m. Steam/Hot Water Heat Exchanger
n. VFD's  
o. Motors  
p. Fans  
q. Fire Dampers  
r. Valves, Traps and Strainers  
s. Water Treatment System  

1.04 ADHESIVES AND SEALANTS  
A. Adhesives, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2005 for volatile organic compound content limits.  
B. Aerosol adhesives shall comply with GS 36-2011 for volatile organic compound content limits.  

1.05 REGULATORY REQUIREMENTS  
A. Perform Work specified in Division 23 in accordance with standards listed below of the latest applicable edition adopted by the authority having jurisdiction. Where these Specifications are more stringent, they shall take precedence. In case of conflict, obtain a decision from the Architect.  
3. ANSI Handicapped Code-A117.1  
4. IBC: International Building Code, with Mechanical and Plumbing Codes.  
5. Special regulations, supplement, and amendments of the State and/or local authorities having jurisdiction.  
B. Comply with the applicable edition date of each regulation as adopted by the authorities having jurisdiction.  

1.06 CONTINUITY OF EXISTING SERVICE AND SYSTEMS  
A. Schedule work so existing systems will not be interrupted when they are required for normal usage of the existing building. Obtain approval from the Owner and Architect at least 7 days prior to any utility interruption or connection.  
B. Perform work at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.  

1.07 PROJECT/SITE CONDITIONS  
A. Layouts indicated on drawings are diagrammatical and intended to show relative positions and arrangement of equipment, ductwork and piping. Coordinate mechanical work with other trades and measurements obtained at the job site, as applicable, prior to installation. Generally,
install work in locations shown on Drawings, using as necessary, rises, drops, offsets, transitions, and alternate routings to fit in the available space unless prevented by Project conditions.

1.08 COMPLETENESS OF WORK

A. The Contract Documents depict HVAC systems which are intended to be complete and functioning systems. All products, materials, and labor necessary to render a fully functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.

B. Catalog numbers referenced throughout the Division 23 Drawings and Specifications are intended to convey a general understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written description shall govern. No extra shall be allowed because a catalog number is found to be incomplete or obsolete.

1.09 RECORD DRAWINGS

A. Provide record drawings that illustrate the work of Division 23 as finally constructed. Provide dimensions of material installed below slab/grade from fixed and visible reference points. Deliver record drawings to the architect in a form suitable for production.

B. Record drawings shall reflect all changes made to the Contract Documents, whether generated by addenda, change orders, or field conditions. Maintain a daily record of these changes and keep current set of drawings showing these changes.

C. Deliver record drawings to Architect within 30 days of Substantial Completion.

1.10 OWNER AND OPERATING MANUALS

A. Comply with the requirements of Division 01, but provide a minimum of three sets, in three ring binders, all sets identical.

B. Manuals shall include clear and comprehensive operating instructions with appropriate graphics and project specific marked data to enable owner to operate and maintain all systems specified in this Division.

C. Copies of approved submittals on furnished equipment shall be included.

PART 2 PRODUCTS

2.01 HANGERS AND SUPPORTS

A. Hangers:

1. General: Complete with rods and supports proportioned to the size of piping or equipment to be supported.
2. For steel pipe: Steel or malleable iron, unless specified otherwise herein.
3. For heating water, 3" and larger: Anvil 171, B-Line B3114, or ERICO 605 roll type with Anvil 160, B-Line B3160, or ERICO 630 pipe covering protection saddles.
4. For copper piping: copper-plates; Anvil CT-69, B-Line B3170 CT, or ERICO 101.
5. For chilled water: galvanized, Anvil 260, B-Line B3100, or ERICO 401.

B. Hanger Rods:
1. One-piece steel type, threaded as required.
2. Sizes, unless specified otherwise herein, shall be as follows:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Rod Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; and smaller</td>
<td>0.375&quot;</td>
</tr>
<tr>
<td>2.5&quot; and 3&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>4&quot;</td>
<td>0.625&quot;</td>
</tr>
<tr>
<td>6&quot;</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>10&quot;-12&quot;</td>
<td>0.875&quot;</td>
</tr>
<tr>
<td>14&quot;-18&quot;</td>
<td>1.0&quot;</td>
</tr>
</tbody>
</table>

3. Sizes for gang or multiple hangers: Calculated for the combined weight of the piping and accessories.
4. Sizes for equipment hangers: Calculated for the weight of the equipment supported.

C. Inserts:
1. Adjustable type: Anvil 282, B-Line B3014, or ERICO 355.
2. Continuous type: Anvil PS-5000, B-Line B321, or ERICO CON.

D. Expansion Anchors:
1. In concrete: Wedge, self-drilling, or drilled flush type.
2. In masonry: Sleeve type.
3. Manufacturer: Hilti, ITW Ramset/Red Head, or Rawl.

E. Insulation Protectors: Anvil 167, B-Line B3151, or ERICO 125.

F. Channel strut systems: 14 gauge minimum galvanized steel, with factory-punched attachment holes. Straps shall be designed so that the attachment nut is captive on the shoulder of the strap when tightened. Attachment nuts shall be designed to provide a surface on the turned down edge while making positive contact with the side walls of the channel. Nuts, bolts, straps, and accessories shall be protected with same finish as channels.
1. Manufacturer: B-Line, Kindorf, Midland-Ross, or Unistrut.

G. Pipe Stand Supports:
1. For chilled water piping: adjustable pipe saddles, stanchion type with locknut nipple, reducer, flange and baseplate. Provide U-bolt yoke for pipe 12" and smaller.
2.02 EQUIPMENT SUPPORTS

A. Structural steel for supports: ASTM A36.
   1. Use galvanized members installed in fan plenums or areas of high humidity or condensation, and outside.
   2. Furnish other members with shop coat of red primer.
   3. Retouch primer after field welding.

2.03 FLASHINGS AND COUNTERFLASHINGS

A. Furnish materials and coordinate installation for flashing and counterflashing roof penetrations for vents, pipe, drains, and ducts.

PART 3 EXECUTION

3.01 EXCAVATING AND BACKFILLING

A. Provide trenching, excavating, and backfilling necessary for performance of mechanical work in accordance with Division 02.

3.02 CUTTING AND PATCHING

A. Repair or replace damage caused by cutting or installation of work specified in Division 23.

B. Perform repairs with materials which match existing and install in accordance with the appropriate section of these specifications.

3.03 FLASHING AND COUNTERFLASHING

A. Counterflash ducts and pipes where penetration of roofs and outside walls occur.

3.04 DELIVERY, STORAGE, AND PROTECTION

A. Insofar as possible, deliver items in manufacturer’s original unopened packaging. Where deliver in original packaging is not practical, provide cover and shielding for all items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storing to keep items from being damaged.

B. Store items in a clean, dry place, and protect from damage. Mechanical equipment may not be staged or stored outdoors unless intended for outdoor use.

C. Protect nameplates on motors, pumps, and similar equipment. Do not paint or insulate over nameplate data.
D. Protect valves and pipping from damage. Cover equipment during work of finishing trades.

E. Keep dirt and debris out of pipes and ducts.

F. Repair, restore, and replace damaged items.

G. Cover factory finished equipment during work of finished trades, such as fan coils, fin tubes, etc.

H. Protect cooling and/or heating coils with temporary filter media during construction.

3.05 OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. Install specified filters prior to system operation. In addition to specified filters, install a roughing filter upstream of mixed air filter. Roughing filter shall consist of two layers of roll filter media clipped and sealed to entering side of filter frame (MERV 8 minimum). Change roughing filter as necessary to minimize dust collection on specified filters.

B. Cover and return and exhaust air grilles with temporary filter media (MERV 8 minimum). Attach media to avoid damage to grille or ceiling. Change temporary media as required to protect against dust buildup on ductwork. Remove temporary media from grilles after flooring is installed, walls are sanded and painted and other dust generating construction has been completed.

C. During period of excessive dust generation such as drywall sanding, seal off return and exhaust openings and grilles to prevent dust from accumulating in ductwork.

D. Furnish and install a new set of specified filter media prior to start of system test and balance. Furnish a new, clean set of the specified media and turn over to Owner's Representative.

3.06 EQUIPMENT GUARDS

A. Use suitable structural frames with minimum 12 gauge, 3/4” galvanized mesh, or expanded metal mesh. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.

B. At belts, provide opening for measuring RPMs.

C. Provide at all belts, couplings, moving machinery and equipment.

D. Design for easy access to belts and other items required replacement.

E. Comply with OSHA regulations.
3.07 CLEANING HVAC SYSTEMS

A. General Cleanup:
   1. Upon completion of contract and progressively as work proceeds, clean up dirt, debris, oil materials, etc., and remove from site, keeping premises in neat and clean condition to satisfaction of the Architect.
   2. Seepage, discoloration or other damage to parts of the building, its finish, or furnishings due to Contractor's failure to properly clean piping systems or duct systems shall be repaired without cost to the Owner.

B. Factory Finishes:
   1. Clean items with factory finishes. Touch up bare places, scratches and other minor damage to finishes. Use only factory supplied paint of matching color and formula. If finishes are badly damaged or if there are many damaged, scratched or bare places, refinish the entire item.

C. Ducts and Apparatus:
   1. Thoroughly clean ducts and apparatus casings before fans and filters are operated.

3.08 CLEANING

A. Thoroughly clean ductwork and equipment casings before fans and filters are operated.

B. Repair damaged factory finishes covering all bare places and scratches.

C. Cleaning HVAC Systems Water Piping:
   1. Clean all equipment and piping of iron cuttings and other foreign matter as they are installed.
   2. Thoroughly flush HVAC water systems with precleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of precleaner chemicals recommended by water treatment supplier and add and circulate throughout the water systems. Drain, refill, and flush water systems thoroughly until no foreign matter is observed and total alkalinity of the drain water is equal to that of the make-up water.
   3. Do not install devices in which foreign matter could become lodged such as control valves, until cleaning and flushing are completed. Position valves to bypass chiller and boiler. Connect supply and return runouts together at each coil location. Make connection of supply and return runouts with short lengths of high pressure rubber hose and brass fittings. One fitting shall be swivel type to eliminate turning fitting in hose.
   4. Fill system at city water make-up connection with all air vents open. After filling, close vents.
   5. Start main pump with pressure reducing valve makeup open.
Check vents in sequence to bleed off any trapped air in order to assure circulation through all components of system. Verify pumps are properly aligned and bolted down before start-up to prevent damage to seals or couplings. Circulate water for at least two hours and then drain completely to flush out foreign matter.

6. Remove, clean, and replace all strainer baskets. Clean all dirt legs. If indications are found of excessive dirt, repeat the above flushing.

7. Fill the system with fresh water, adding precleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of precleaner chemicals recommended by water treatment supplier. Alternate operation of primary and standby pumps, and circulate the cleaning solution for 24 hours. Then turn off the pump and completely drain the system.

8. Remove, clean, and replace all strainer baskets. Clean all dirt legs. Replace suction diffuser start-up strainer with conventional strainer. Refill the system with clean water, venting all high points and equipment of air and gases. Bring water systems to operating temperature. Recheck all vent points during this process and remove all air.

9. After the system has been completely cleaned, test system by litmus paper or other dependable method and leave system on slightly alkaline side (ph 7.5 to 8.5). If system is still on acid side (ph 7.0 or lower), add water conditioner.

3.09 TESTING MECHANICAL SYSTEMS

A. Test all systems and equipment installed to demonstrate proper operation.

B. Advise Architect of scheduled systems testing and completed system demonstration/operation schedules so that he may witness, if desired.

C. Correct and retest work found defective when tested.

D. Make repairs to piping systems with new materials. Peening, doping, or caulking of joints or holes will not be acceptable.

E. HVAC Circulating Water Piping: Hydrostatically test piping at 150 psig pressure or at 1-1/2 times design pressure as indicated on drawings, whichever is greater, for a period of six hours without evidence of leaking.

F. Records of Testing: Maintain records of system testing and results thereof. Deliver results as part of project closing file and on an intermediate basis as requested by Architect.

END OF SECTION
SECTION 23 05 05

USE OF MECHANICAL SYSTEMS

PART 1  GENERAL

1.01  GENERAL

A. Provide all labor, materials, tools, and services required; maintain warranties and keep equipment in operating condition.

B. Principal equipment included are:
   1. Chillers
   2. Pumps
   3. Air Handling Units
   4. Fan Coil Units
   5. Variable Air Volume Boxes
   6. Variable Frequency Drives (VFD)
   7. Fans
   8. Air Distribution Devices
   9. Control System

C. No mechanical equipment shall be operated until the equipment has been started, approved and signed off by the equipment's respective supplier.

D. Air handlers shall be operated only in areas where painting and ceiling work is in progress. Air handlers shall not be operated when concrete grinding or drywall finishing is in progress.

E. When an air handler is placed in service, pre-filters shall be changed on a weekly basis. The Contractor shall maintain logs showing when filters are changed.

F. Air handlers shall not be operated over 30 Hz until factory start up is complete and copies of the start up report are provided to the Designer for approval.

G. The chillers shall not be operated until factory start up is complete and copies of the start up report are provided to the Designer for approval.

H. After start up of the chillers, the contractor shall visit the site at least three times a day to inspect and fill out Owner's equipment logs.

I. The chillers shall not be operated until the water treatment systems are fully functional.

J. If air handling units are used during construction, filtration media with a minimum efficiency of MERV8 shall be used at each return grille.

K. Protect all HVAC equipment from both dust and odors.
L. Seal all duct and equipment openings with plastic. Protect the return/negative pressure side of all systems. Install and maintain (replace weekly) temporary filters over grilles and openings. The temporary filters shall have a rating of MERV8 or better.

1.02 CLEANING

A. Thoroughly clean ductwork, equipment casings, coils and VAV boxes and replace filters before turning equipment over to the Owner. Units having visible signs of construction dust will not be accepted.

B. Repair damaged factory finishes covering all bare places and scratches.

C. Thoroughly clean chilled water and hot water systems before system is turned over to the Owner.

PART 2 PRODUCTS - NOT APPLICABLE

PART 3 EXECUTION - NOT APPLICABLE

END OF SECTION
SECTION 23 05 13

MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1  GENERAL

1.01  SUBMITTALS

A. Submit motor information with submittals and shop drawings.

1.02  REFERENCE STANDARDS

A. All equipment and material furnished and installed on this project shall be UL or ETL listed in accordance with the requirements of the authorities having jurisdiction and suitable for its intended use on this project.

PART 2  PRODUCTS

2.01  MOTORS

A. Acceptable manufacturers: MagneTek or Lincoln.

B. In general, motor voltages shall be as follows, unless specified or indicated otherwise:
   1. 3/4 hp and larger: 208V or 460V, three (3) phase, 60 hertz (reference drawings)
   2. Smaller than 3/4 hp: 120V, one (1) phase, 60 hertz

C. All motors shall be started across the line, unless specified otherwise. Motors shall be selected with low starting current and shall be designed for continuous duty to provide the running torque and pull in torque required to suit the load. Unless otherwise indicated on the Contract Documents, all motors shall be single speed (1750 rpm). All motors shall have standard open drip proof enclosures unless otherwise specified. All motors exposed to the actually installed outside in the weather shall be of the totally enclosed fan cooled (TEFC) or totally enclosed air over (TEAO) types. All motors not utilized with variable speed drives shall have a minimum service factor of 1.15 and shall be selected to operate at design conditions without exceeding their nameplate rating (without exploiting the service factor rating). Motors used in conjunction with variable speed drives shall have a 1.00 service factor unless otherwise indicated and be compatible with the drive and rated for inverter output duty.
   1. Standard open drip proof three (3) phase motors ten (10) horsepower and smaller shall have cast aluminum end bells with steel frames. Three (3) phase motors fifteen (15) horsepower and larger shall have cast iron end bells and housings.
   2. Standard open drip proof single phase motors shall have cast aluminum end bells with steel frames.
   3. Totally enclosed fan cooled (TEFC) and totally enclosed air over (TEAO) three (3) phase motors shall have cast iron housings. TEFC motors shall have corrosion resistant fans.
D. Windings and Insulation:
   1. All motors shall have copper windings.
   2. Motors shall be equipped with Class B, 80°C rise or Class F, 105°C rise insulation suitable for use in a 40°C ambient temperature. Windings shall be treated with an epoxy varnish to inhibit the absorption of moisture.

E. Bearings:
   1. Single phase, fractional horsepower motors shall be equipped with quiet operating, all angle, babbitt lined sleeve bearings.
   2. Polyphase motors shall be equipped with deep groove type ball bearings, generously sized for the loads to which applied and for severe duty application. Provide the necessary seals on the shaft to keep the bearing system free of contamination and moisture. Lubricant shall be high temperature, nonbleeding grease.
      a. Provide inlet and outlet plugs on poly-phase motors so that grease fittings can be easily inserted for bearing relubrication except as otherwise specified. The end shields shall be carefully machined to add extra grease capacity. Lower outlet plugs shall be equipped with combination breather/drains on TEFC and TEAO motors.

F. Motors shall be specifically designed for quiet operation and for severe duty. Standard open drip proof motors shall be equipped with aluminum or stainless steel stamped nameplates. Totally enclosed fan cooled and air over motors shall be equipped with stainless steel stamped nameplates with either zinc or cadmium plated hardware. Motor nameplates shall clearly indicate frame size, horsepower, frequency, voltage, speed, starting torque class, insulation class, service factor and winding material.

G. Motors on belt driver equipment shall have slide rails with adjusting screws for belt tension adjustment. Motors exposed to the weather shall be weather protected.

H. Motors specified with variable frequency drive controllers shall be inverter duty rated and shall be insulated against eddy currents.

I. Install premium efficiency electric motors for motors 1 horsepower and above. Premium efficiency motors shall have efficiency and losses determined in accordance with the latest revisions of IEEE Standard 112. Polyphase squirrel-cage motors rated 1 through 125 horsepower shall be tested by dynamometer method B. The efficiency will be determined using segregated losses in which stray load loss is obtained from a linear regression analysis to reduce the effect of random errors in the test measurements. Guaranteed minimum load efficiency shall be as follows:
   1. HP: 3/4 Eff: 80%
   2. HP: 1 Eff: 84%
   3. HP: 1-1/2 Eff: 86.5%
   4. HP: 2 Eff: 86.5%
   5. HP: 3 Eff: 89.5%
6. HP:  5  Eff:  89.5%
7. HP:  7-1/2  Eff:  91.7%
8. HP:  10  Eff:  91.7%
9. HP:  15  Eff:  93.0%
10. HP:  20  Eff:  93.6%
11. HP:  25  Eff:  93.6%
12. HP:  30  Eff:  94.1%
13. HP:  40  Eff:  94.5%
14. HP:  50  Eff:  95.0%
15. HP:  60  Eff:  95.4%
16. HP:  75  Eff:  95.4%

J. Sound power levels not greater than recommended in NEMA M61-12.49. VFD duty rated motors shall not increase by more than 3 dB when operating on VFD.

K. Provide motors with drive shafts long enough to extend completely through belt sheaves when sheaves are properly aligned or balanced.

2.02 STARTERS

A. Starters shall be as manufactured by Square D or approved substitute.

B. Starters used on 208-volt systems shall have two cartridge fuses in the control circuit.

C. Starters used on 480-volt systems shall have an individual 480/120-volt control transformer with two cartridge fuses in the primary and one in the secondary.

D. All starters to be provided with melting alloy overloads.

E. Starters used inside shall have NEMA 1 enclosures; starters used in damp locations or exposed to the weather to have NEMA 3R enclosures.

F. Manual Motor Starter with Heater Unit: Square D Class 2510.

G. Provide starters with disconnect switch.

H. Starters mounted in motor control center are specified under Division 26.

I. Single speed motors 25 horsepower and larger to have power factor correction capacitors.

PART 3 EXECUTION

3.01 INSTALLATION

A. Arrange and set motors.

B. Line up motors on direct drive equipment using dial type gauges.
C. Make connections and test motor for proper rotation/phasing under Division 26.

3.02 ADJUSTMENTS

A. Motors, together with driven equipment, shall be dynamically and statically balanced. Imbalance shall be reduced to minimum specified by equipment manufacturers.

B. Fan vibration should be limited to manufacturer's recommendations, but should not exceed 2 mils in any case.

END OF SECTION
SECTION 23 05 14

VARIABLE FREQUENCY MOTOR DRIVES

PART 1  GENERAL

1.01  GENERAL

A. Furnish complete variable frequency motor controllers (VSMC) for fans and pumps designated.

1.02  WARRANTY

A. The VSMC shall be warranted by the manufacturer for a period of 36 months from date of start-up. The warranty shall include parts and labor.

B. During warranty period, any warranty expense shall be born by the manufacturer, including travel costs or living expenses necessary to repair in warranty equipment.

PART 2  PRODUCTS

2.01  ACCEPTABLE MANUFACTURERS

A. ABB or approved equal.

2.02  DRIVE TECHNOLOGY

A. Solid state design to transform input power into frequency and voltage controlled 3-phase output power suitable to provide positive speed and torque control to standard induction motors.

B. Front end: Input line filters as integral part of drive.

C. Invertor section: Transistorized sinecode pulse width modulation. Employ power transistors in the invertor without paralleling.

D. Power factor: Minimum of .95 and an efficiency of 95% at 100% full output.

E. Increase in audible motor noise with drive operating shall not exceed 3 decibels.

2.03  EQUIPMENT REQUIREMENTS

A. Enclosure: NEMA 1 enclosure with deadsides for installation in an individual wall installation.

B. Input disconnect: Integral, magnetic trip only circuit breaker or non-fused switch.

C. Ratings: 1. Provide symmetrical A/C rating of 100,000 amps for fused input drives.
2. Provide symmetrical A/C ratings of 50,000 amps for other than fused input drives at 460 volts and 35,000 amps for other than fused inputs at lower voltages.

3. Provide higher ratings where available fault current exceeds these levels and as called for on drawings.

D. Provide an integral bypass contactor for operation of motor at constant speed, electrically independent of the inverter. Include motor overload protection when in bypass mode. Include necessary control relays and switches to allow automatic controls and safeties to operate when drive is in bypass mode.

E. Features and Specifications:
   1. Horsepower Rating: As scheduled on drawings.
   2. Input power: 460 VAC +/- 10%, 60 HZ +/- 3%.
   3. Output power: 0-460 volts, 1-60 HZ.
   4. Ambient temperatures:
      a. Drive operating: 32 degrees F. to 104 degrees F.
      b. Drive storage: 68 degrees F. to 140 degrees F.
   5. Output Frequency Stability: Shall not vary with load, temperature or with +/- 10% input frequency variations.
   6. The VSMC shall include a plug-in test meter for monitoring the different signals within the VSMC for start up and troubleshooting.

F. Speed Control:
   1. The output frequency may be adjusted in proportion to any one of the following:
      a. 0-10 VDC Analog Signal.
      b. 0-5 VDC Analog Signal.
      c. 4-20 MA DC Analog Signal.

G. Start-Stop Control: Drive may be started or stopped by any one of the following:
   1. A contact closure.
   2. Use of a motor starter or contactor in the input power line.
   3. The speed control signal dropping below or rising above minimum.
   4. An external 115 VAC signal.

H. Customer Contacts: Single pole, double throw contact which changes state on trip condition.

I. 115 Volt AC Power Supply: Used to provide a remote enabled indication.

J. Building Automation System Interface: Provide VFD interface to duplicate all points monitored locally at VFD into the BAS. Interface shall connect to BAS network communication bus.

2.04 SELF PROTECTION AND RELIABILITY FEATURES

A. Current Limit: Limit output current to 110% of inverter rating.

B. Instantaneous Overcurrent Trip: Limit output current in under 50 microseconds due to phase-to-phase short circuits or severe overload conditions.
C. Undervoltage Trip: Protect the inverter due to voltage levels in excess of its rating. Activates automatically when the DC bus in the controller exceeds 1000 VDC.

D. Overtemperature Trip: Protect the inverter from elevated temperatures in excess of rated temperatures.

E. Automatic Reset/Restart:
   1. Automatic reset on trip condition resulting from overcurrent, undervoltage, overvoltage, or overtemperature after removal or correction of the causative condition.
   2. Provide unlimited number of reset/restarts for undervoltage, overvoltage, and overtemperature.
   3. Limit the number of reset/restarts for overcurrent and require manual reset.

F. Isolation: Isolated current and voltage signals from logic circuitry.

G. Drive Logic: Microprocessor based.

H. Sustained Power Loss: In the event of a sustained power loss, shut down without component failure. Upon return of power, automatically return drive to normal operation if the start is in the "ON" condition.

I. Momentary Power Loss: In the event of a momentary power loss, shut down without component failure. Upon return of power, automatically return drive to normal operation, if the start is in the "ON" condition, being able to restart into a rotating motor regaining positive speed control without shutdown or component failure.

J. Short Circuit Protection: In the event of a phase-to-phase short circuit, shutdown safely without component failure.

K. Power Interruption: In the event that an input or output power contactor is opened or closed while the drive is activated, no damage to the control shall result.

L. Critical frequency avoidance circuit: Minimum of six user selectable bands to avoid operation at speeds which cause excessive vibration or noise in the driven equipment.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Install and connect equipment in locations specified on Contract Drawings in strict accordance with the manufacturer's instructions.

B. Provide materials and assistance as required by the manufacturer's representative.
C. Coordinate installation with requirements for HVAC temperature controls.

D. Electrical:
   1. Control systems, components and control and interlock wiring for mechanical equipment will be furnished under this division.
   2. Provide power wiring to drives under Division 26. Power wiring shall consist of wiring to the line side terminals wiring away from the load side terminals to the equipment, except where such wiring is installed pre-wired by the equipment vendor such as for chiller units.
   3. Fire alarm control wiring among duct mounted smoke detectors, fire alarm system, drives, ATC panels DDC panels shall be furnished under Division 28.

E. Label enclosures with engraved plastic nameplate describing the equipment served, e.g. "AHU-1". Nameplates shall be attached with screws or rivets. Adhesives shall not be used to secure the nameplates.

3.02 START-UP, TESTING, DEMONSTRATION

A. Provide a factory trained technician to supervise the installation, start-up and testing of drives. As a minimum, check the following items:
   1. Motor voltage and frequency.
   2. Control input and automatic start/stop.
   3. Calibration and adjustment for minimum and maximum speed set points and acceleration and deceleration rates.

B. Provide a minimum of one day (8 hours) instruction to maintenance personnel.

C. Demonstrate the operation of the system to the maintenance personnel.

D. Provide the necessary coordination for test and balance procedure as required by Section 23 05 93.

END OF SECTION
SECTION 23 05 17

SLEEVES, ESCUTCHEONS, AND SLEEVE SEALS FOR HVAC PIPING

PART 1  GENERAL (Not Applicable)

PART 2  PRODUCTS

2.01  SLEEVES

A.  Sleeves shall be standard weight steel pipe except sleeves for concealed piping through floors not in structural members, and through interior dry-wall construction may be formed from 26 gauge galvanized sheet metal lapped and pop riveted.

2.02  EXTERIOR WALL - SLEEVE-SEAL SYSTEMS

A.  Exterior Wall & Steam Vault Penetration System by Link-Seal or approved equal.

B.  Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1.  Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2.  Pressure Plates: Carbon steel.
   3.  Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03  SLEEVES

A.  Materials
   1.  Concrete floors, concrete and masonry walls: 18 gauge galvanized sheet metal.
   2.  Drywall partitions: 18 gauge galvanized steel sheet metal

B.  Sleeves shall be sized such that the annular space between outside surface of pipe or pipe insulation and the inside surface of the sleeve is not less than 1/2". Provide larger annular space if required by firestopping product installation instructions

C.  Sleeves supporting riser piping 4" and larger shall have three 6" long reinforcing rods welded radically at 120 degree spacing to the sleeve and shall be installed with the rods embedded in the concrete slab

2.04  PENETRATION SEALS

A.  Refer to architectural specification for Fire Safing.
2.05 GROUT

A. Non-shrink type, conforming to ASTM C1107/C1107M-2013 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psi.

B. Manufacturer: Cormix or Master Builders.

2.06 ESCUTCHEON PLATES

A. Provide chromium plated escutcheon plates for exposed, uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electrical closets and janitor closets are not considered "finished" spaces.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
   1. Piping requiring sleeves:
      a. Heating hot water
      b. Chilled water
      c. Copper pipes thru masonry walls

B. Where a pipe requiring sleeves passes through a wall, ceiling or floor slab, a steel sleeve shall be provided and the internal diameter of the sleeve shall be 2" larger than the external diameter of the pipe or insulated pipe passing through it. After all the piping is installed in that area, the Contractor shall check the clearance and correct it, if necessary to within 1/2". Then the void shall be packed full depth with glass/mineral fiber and sealed at both ends, 1" deep with sealant backed by foam rod. Nothing in these paragraphs shall override the fire penetration details shown on the drawings.

C. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2" in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.
   1. Sleeves are not required for core-drilled holes.

D. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
E. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

F. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.03 ESCUTCHEONS

A. Provide escutcheons where exposed piping passes through walls, floors, and ceilings in finished areas.

3.04 SLEEVES

A. Floors: Sleeve all pipe penetrations. Extend sleeve 1-1/2" above finished floor, except piping within pipe chases. Sleeve shall be flush with underside of floor.

B. Masonry or concrete walls: Sleeve all pipe penetrations. Sleeves shall be flush on both sides of wall.

C. Drywall partitions: Sleeve all penetration of piping in systems over 160 degree F.

D. Seal voids between outside surface of sleeve and wall, partition or floor. Seals shall be airtight.

E. Install piping, insulation and sleeves in strict accordance with applicable U.L. floor or partition assembly instructions. Coordinate with Division 07 firestop manufacturer's installation instructions.

F. Penetrations not sleeved or fire-stopped:
1. Seal voids between pipe and partition. Seals shall be airtight.

3.05 ESCUTCHEON PLATES

A. Provide chromium plates escutcheon plates for exposed uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electric closets, and janitor closets are not considered "finished" spaces.

B. Clearance between sleeve and pipe: Minimum of 1/2 inch for hot piping and 1 inch for cold piping or as otherwise dictated by U.L. Fire Resistance Directory.

END OF SECTION
SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL (NOT USED)

PART 2 PRODUCTS

2.01 HANGERS

A. Anvil Figure #260 clevis hangers with Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption.
   1. Hot water piping above 160 degrees F. 4" diameter and less.
   2. Chilled water piping.

B. Anvil Figure #171, MSS Type 41 with pipe roller, Anvil Figure #16x protection saddle and Anvil Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi, at 8 foot intervals). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption. Use these for:
   1. Hot water reheat above 160 degrees F. 6" diameter and larger

C. Anvil Figure #CT-121, MSS Type 8, riser clamps (at floor penetrations) to support:
   1. Copper pipe risers

D. Anvil Figure #261, MSS Type 8, riser clamps (at floor slab penetrations) to support:
   1. Steel pipe risers

E. Anvil Powerstrut Trapeze Hangers: Where three or more lines of pipe run parallel, support them with trapeze hangers, sized for maximum 3/16" deflection.

2.02 INSERTS

A. Concrete Insert: Anvil Figure #281, MSS Type 18, universal concrete inserts, adequately sized and correctly positioned to support full load operating systems.

B. Concrete Insert, Wedge Type: Anvil Figure #281, 1/4" to 7/8".

C. Lightweight Concrete Insert: Anvil Figure #285.

D. Continuous Concrete Insert: Anvil Powerstrut Figure #PS-349 pre-galvanized.
2.03 EXPANSION ANCHORS

A. Hilti Kwik-bolt, zinc plated, metal expansion anchor.
B. Anchor to meet U.L., ICBO-4627 and FM listings.

2.04 CLAMPS

A. C-Clamps: Anvil Figure #92, MSS Type 23.
   1. Use these for attaching hangers to steel beams. Do not weld hanger rods to structural steel members.
B. Malleable Beam Clamps: Anvil Figure #218, MSS Type 30: Use these for attaching hangers to bar joists.

2.05 HANGERS RODS

A. Provide mild steel, all-thread rods with maximum loads as follows:
   1. 3/8" - 300 lbs.
   2. 1/2" - 600 lbs.
   3. 5/8" - 1,200 lbs.
   4. 3/4" - 2,000 lbs.
   5. 1" - 5,000 lbs.

2.06 TRAPEZE PIPE HANGERS

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

2.07 THERMAL-HANGER SHIELD INSERTS

A. Protect insulation at each hanger and support point with a 14 gauge galvanized shield which extends up to the centerline of the pipe and is centered inside the pipe hanger. Minimum shield length shall be 12". Provide a section of foam glass insulation between pipe and metal shield where glass fiberglass insulation is used on 3" and larger.

2.08 FASTENER SYSTEMS

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

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

2.10 UNISTRUT

A. Provide floor mounted Unistrut for variable frequency drives and control panels as required.

2.11 ROOF CURBS

A. Provide prefabricated metal roof curbs at all roof ductwork and piping penetrations and for support of all roof-mounted equipment, fans and ductwork. Construct curbs according to National Roof Contractor's Association guidelines. Prefabricated metal roof curbs shall be manufactured by ThyCurb, Custom Curb, or approved substitute.

B. Construction curbs with minimum 18 gauge galvanized steel (14 gauge for curbs with any side longer than 4'-0" and for all curbs supporting equipment) with fully mitered and welded corners, integral base plate, internal reinforcing with 1" x 1" x 1/8" steel angle for curbs with any side longer than 3'-0", factory installed 1-1/2" thick, 3-pound density fiberglass insulation and factory installed pressure treated wood nailer. Minimum height of curb shall be 12" above finished roof surface. Consult architectural plans for roof type and thickness. Construct curbs to match slope of roof and provide a level top surface for mounting of mechanical equipment. Non-ducted equipment curbs shall be turned such that they are parallel to the slope of the roof (short side faces on-coming water).

C. Curb types shall be as follows:
   1. Fan and duct penetration curbs with standard curb construction as described above - Thy Curb Model TC-3 with no cant.
   2. Equipment support curbs with minimum 18 gauge galvanized steel shell, base plate and counterflashing, wood nailer, and internal bulkhead reinforcement - ThyCurb Model TEMS.

D. Install curbs in strict accordance with manufacturer's published installation instructions and as detailed on the drawings. Coordinate proper curb size, construction, and base prior to fabrication.

2.12 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
PART 3  EXECUTION

3.01  HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.

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

F. Equipment support in first paragraph below requires calculating and detailing at each use.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes, expansion bends, and similar units.

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

J. 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.
K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) 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 (DN 100) and larger if pipe is installed on rollers.

4. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

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

3.02 EQUIPMENT SUPPORTS

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

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

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

3.03 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING

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

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

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified Division 09.

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

3.06 HANGER AND SUPPORT SCHEDULE

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

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

9. 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.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

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

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450°F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. 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.
   8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
   9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
   2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 23 05 33

HEAT TRACING FOR EXTERIOR CHILLED WATER PIPING

PART 1  GENERAL

1.01  SUMMARY

A. Furnish and install a complete U.L. listed system of heaters, components, and controls to prevent chilled water pipe lines from freezing.

1.02  WARRANTY

A. Provide three years warranty from date of Substantial Completion. Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

PART 2  PRODUCTS

2.01  SELF-REGULATING HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating. The heater shall be equivalent to Raychem XL-Trace, Chromalox Rapid Trace or approved equal.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket.

E. Maximum Operating Temperature (Power On): 150 deg F.

F. Maximum Exposure Temperature (Power Off): 185 deg F.

G. 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.

H. Capacities and Characteristics:

<table>
<thead>
<tr>
<th>Diameter of Pipe</th>
<th>Watts/Foot of Pipe @ 40°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch or less</td>
<td>5</td>
</tr>
<tr>
<td>4 to 6</td>
<td>8</td>
</tr>
</tbody>
</table>
2.02 CONTROLS

A. The system shall be controlled by an ambient sensing thermostat set at 40 degrees F. either directly or through an appropriate contractor.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.03 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install electric heating cable across expansion joints in strict accordance with manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Equipment and Piping Insulation."
E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Ground fault equipment according to Section 427-22 of the National Electric Code.

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

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   2. Test cables for electrical continuity and insulation integrity before energizing.
   3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Remove and replace damaged heat-tracing cables.

END OF SECTION
SECTION 23 05 48

VIBRATION ISOLATION FOR HVAC

PART 1  GENERAL

1.01  SUMMARY

A. Isolate equipment as specified herein with factory-fabricated vibration isolators. Provide isolators of proper sizes and weight to meet the requirement.

PART 2  PRODUCTS

2.01  ACCEPTABLE MANUFACTURERS

A. Kinetics Noise Control or Mason Industries. Provide isolators by a single manufacturer.

2.02  FIBERGLASS OR NEOPRENE PADS

A. Provide Kinetics Model KIP
   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.
   5. Infused nonwoven cotton or synthetic fibers.

B. Provide isolation pads for:
   1. Chilled water pumps.
   2. Hot water pumps.

2.03  SPRING AND RUBBER ISOLATION HANGERS

A. Provide Kinetics Model SFH or SRH for:
   1. Suspended square in-line centrifugal fans (minimum 1.0" deflection).
   2. Suspended unit heaters (minimum 1.0" deflection).
   3. First three (3) piping hangers on each side of air handling units and pumps (minimum 1.5" deflection).
   4. Suspended centrifugal in line fans (minimum 2" deflection)

2.04  FLEXIBLE PIPE CONNECTORS
A. Provide Metraflex or approved substitute twin-sphere flexible rubber pipe connectors with female unions or floating flanges on piping connections to equipment subject to vibration.

B. Provide connectors rated for 150 PSI working pressure.

C. Provide flexible pipe connectors for the following:
   1. Water connections to pumps.
   2. Water connections to air handling units.
   3. Water connections to air cooled chillers.

2.05 OUTDOOR APPLICATIONS

A. All isolators located outside exposed to weather shall be corrosion resistant construction with hot dip galvanizing or PVC coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install vibration isolation in accordance with the isolator and equipment manufacturer's published installation instructions.

B. Size vibration isolation in accordance with weight distribution, pull or the imposed torque of actual equipment provided.

END OF SECTION
SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1  GENERAL

1.01  SUMMARY (Not Applicable)

PART 2  PRODUCTS

2.01  NAMEPLATES AND TAGS

A.  Acceptable manufacturers:  Seton Nameplate Corporation or Marking Services Inc.

B.  Rigid plastic, "Setonite" or bakelite with engraved lettering, minimum 1/2" high.

2.02  PIPE MARKERS

A.  Plastic Pipe Markers:  Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering.

2.03  PIPE IDENTIFICATION

A.  Identify piping with Snap-on or Strap-on type markers as manufactured by Seton or approved substitute.  Indicate contents of pipe and direction of flow on marker.  Install markers on piping not more than 20 feet apart, at valves, access panels and above each space.  Identify chilled water and hot water piping.

B.  All piping in equipment rooms and concealed in accessible spaces (such as piping above lay-in ceiling space) shall be labeled to identify contents and direction of flow.

2.04  EQUIPMENT AND APPARATUS IDENTIFICATION

A.  Acceptable Manufacturers:  Seton Name Plate Corporation or equal.

B.  Nameplates:  Rigid plastic, "Setonite" or bakelite, with engraved lettering (indicating names and numbers of mechanical apparatus), a minimum of 1/2" high.  Fill engraved lettering with a permanent coloring material which contrasts with color of tag material to allow for easy reading.

C.  Use names, numbers, and abbreviations appearing in schedules on Contract Drawings.

D.  Provide nameplates, located in a conspicuous location directly on the equipment or apparatus, for mechanical equipment including, but not limited to:

1.  Chillers
2. Boilers
3. Air Handling Units
4. Variable Volume Terminals
5. Starters
6. Variable Frequency Drives
7. Pumps
8. Fans
9. Fan Coil Units
10. HVAC Equipment
11. Control Panels

E. Equipment Tags: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws, or rivets. Identification tags shall be constructed of engraving stock melamine plastic laminate, 1/8" minimum thickness, black and white core (letter color) punched for mechanical fastening. Letter height shall be minimum 1/2" tall.

F. Control Diagram Frames:
1. Seton Name Plate Corporation, No. 111P aluminum frames, or equal by Brady or Avery, with "plexiglass" or "lucite" glazing.
2. Provide control and systems instructions and diagrams, framed and glazed with specified items. Mount framed diagrams on walls in conspicuous, easily accessible places in each separate mechanical room housing an A/C systems to which the individual diagrams are applicable. The following instructions and diagrams are required:
   a. Control diagrams.
   b. Wiring diagrams.
   c. Sequence of operation, where applicable.
3. Diagrams and instructions may be reduced in size provided they are easily readable and lettering is not smaller than "10 pt." type.

PART 3 EXECUTION (Not Applicable)

END OF SECTION
SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1  GENERAL

1.01  SERVICES

A. The balancing agency shall inspect the installation of the piping systems, sheet metal work, and the temperature controls. A minimum of two inspections shall be performed periodically as work progresses.
   1. When 50 percent of the ductwork and piping is installed.
   2. When 50 percent of the equipment is installed.

B. Perform test and balance in accordance with AABC or NEBB Standards.

C. The TAB Contractor shall work with the Control Contractor to assist in calibrating all airflow and water flow stations and duct and pipe mounted differential pressure sensors and duct mounted temperature sensors.

D. The Contractor shall provide Test and Balance Agency with copy of plans and specifications of Construction Documents. The Contractor shall correct prompt deficiencies of materials and workmanship identified as delaying the completion of the TAB work. The Contractor shall be responsible for any additional costs to the Owner resulting from his failure to have the HVAC systems and Building ready or from his failure to correct deficiencies promptly.

PART 2  PRODUCTS

PART 3  EXECUTION

3.01  EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output,
and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine variable-air-volume boxes, and hot water coils. Verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. 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.
3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures for balancing the systems.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Airside:
      a. Duct systems are complete with terminals installed.
      b. Volume fire dampers are open and functional.
      c. Clean filters are installed.
      d. Fans are operating, free of vibration, and rotating in correct direction.
      e. Variable-frequency controllers’ startup is complete and safeties are verified.
      f. Automatic temperature-control systems are operational.
      g. Ceilings are installed.
      h. Windows and doors are installed.
      i. Suitable access to balancing devices and equipment is provided.

   2. Hydronics:
      a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
      b. Piping is complete with terminals installed.
      c. Water treatment is complete.
      d. Systems are flushed, filled, and air purged.
      e. Strainers are pulled and cleaned.
      f. Control valves are functioning per the sequence of operation.
      g. Shutoff and balance valves have been verified to be 100 percent open.
      h. Pumps are started and proper rotation is verified.
      i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
      j. Variable-frequency controllers’ startup is complete and safeties are verified.
      k. Suitable access to balancing devices and equipment is provided.

3.03 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 Total System Balance" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233713 "Sheet Metal Specialties."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation" and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 and 233115.
PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:
   1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
   2. Verify that the system is under static pressure control.
   3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
      a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
      b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
      c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
      d. Adjust controls so that terminal is calling for minimum airflow.
      e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
      f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
   5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflow within the maximum allowable fan speed listed by fan manufacturer.
      a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
      b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
      c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
      d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
      e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
   6. Measure fan static pressures as follows:
a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.

9. Verify final system conditions as follows:
   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
   d. Mark final settings.
   e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
   f. Verify tracking between supply and return fans.

3.06 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
   1. Check liquid level in expansion tank.
   2. Check highest vent for adequate pressure.
   3. Check flow-control valves for proper position.
   4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
   5. Verify that motor starters are equipped with properly sized thermal protection.
   6. Check that air has been purged from the system.
A. Adjust pumps to deliver total design gpm.
   1. Measure total water flow.
      a. Position valves for full flow through coils.
      b. Measure flow by main flow meter, if installed.
      c. If main flow meter is not installed, determine flow by pump
         TDH or exchanger pressure drop.
   2. Measure pump TDH as follows:
      a. Measure discharge pressure directly at the pump outlet
         flange or in discharge pipe prior to any valves.
      b. Measure inlet pressure directly at the pump inlet flange or
         in suction pipe prior to any valves or strainers.
      c. Convert pressure to head and correct for differences in
         gage heights.
      d. Verify pump impeller size by measuring the TDH with the
         discharge valve closed. Note the point on manufacturer's
         pump curve at zero flow, and verify that the pump has the
         intended impeller size.
      e. With valves open, read pump TDH. Adjust pump discharge
         valve until design water flow is achieved.
   3. Monitor motor performance during procedures and do not operate
      motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design
   water flows.
   1. Measure flow in main and branch pipes.
   2. Adjust main and branch balance valves for design flow.
   3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to
   design water flows.
   1. Measure flow at terminals.
   2. Adjust each terminal to design flow.
   3. Re-measure each terminal after it is adjusted.
   4. Position control valves to bypass the coil, and adjust the bypass
      valve to maintain design flow.
   5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:
   1. Measure differential pressure and verify that it is within
      manufacturer's specified range.
   2. Perform temperature tests after flows have been verified.

E. Verify final system conditions as follows:
   1. Re-measure and confirm that total water flow is within design.
   2. Re-measure final pumps' operating data, TDH, volts, amps, and
      static profile.
   3. Mark final settings.

F. Verify that memory stops have been set.
3.08 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:
   1. Verify that the differential-pressure sensor is located as indicated.
   2. Determine whether there is diversity in the system.

C. For systems with no diversity:
   1. Adjust pumps to deliver total design gpm.
      a. Measure total water flow
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
      b. Measure pump TDH as follows:
         1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
         2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
         3) Convert pressure to head and correct for differences in gage heights.
         4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
         5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
   2. Adjust flow-measuring devices installed in mains and branches to design water flows.
      a. Measure flow in main and branch pipes.
      b. Adjust main and branch balance valves for design flow.
      c. Re-measure each main and branch after all have been adjusted.
   3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
      a. Measure flow at terminals.
      b. Adjust each terminal to design flow.
      c. Re-measure each terminal after it is adjusted.
      d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
      e. Perform temperature tests after flows have been balanced.
   4. For systems with pressure-independent valves at terminals:
      a. Measure differential pressure and verify that it is within manufacturer's specified range.
      b. Perform temperature tests after flows have been verified.
5. Prior to verifying final system conditions, determine the system differential-pressure set point.

6. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

7. Mark final settings and verify that all memory stops have been set.

8. Verify final system conditions as follows:
   a. Re-measure and confirm that total water flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
   c. Mark final settings.

9. Verify that memory stops have been set.

3.09 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
   2. Air Outlets and Inlets: Plus or minus 5 percent.
   3. Heating-Water Flow Rate: Plus or minus 5 percent.
   4. Cooling-Water Flow Rate: Plus or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.10 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings including settings and percentage of maximum pitch diameter.
    e. Settings for supply-air, static-pressure controller.
    f. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

j. Number, make, and size of belts.

k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

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. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Chiller test forms - Record the following items for each chiller:
   1. Manufacturer, model number, and serial number
   2. All design and manufacturer's rated data.
   3. Rated and actual pressure drop across evaporators and condensers and related GPM.
   4. Entering and leaving water temperatures for the evaporator and condenser.
   5. Rated and actual operating current and voltage.

G. Chiller:
   1. Record full load entering and leaving chilled water temperatures with glass stem, mercury thermometers accurate to 1/2 degree F.
   2. Record GPM at time of test.
   3. Record amperage and voltage.
   4. Perform log-test for a minimum of one hour taking readings at least every ten minutes.
   5. Average all readings and compute test capacity in BTU/HR. and in tons.
   6. Average all readings and compute actual kw/ton of chiller.

H. Boiler test forms - Record the following items on each boiler test form:
   1. Manufacturer and model number.
   2. All design and manufacturer's rated data.
   3. Service and location.
   4. Actual pressure drop and related GPM, primary side.
5. Actual pressure drop and related GPM, secondary side.
6. Primary side entering and leaving temperatures.
7. Secondary side entering and leaving temperatures.
8. Temperature control setting.

I. Pump test forms - Submit pump curve showing design - operating - and no-flow points of operation. Also, record the following items on each pump test form:
   1. Manufacturer, size, and serial number.
   2. All design and manufacturer's rated data.
   3. Pump operating suction and discharge pressure and final total dynamic head.
   4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size.
   5. Rated and actual operating current, voltage, and brake horsepower of each pump motor as well as starter and heater data.

J. 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 (DN).
      i. Tube and fin materials.
      j. Circuiting arrangement.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Average face velocity in fpm.
      c. Air pressure drop in inches wg.
      d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
      e. Return-air, wet- and dry-bulb temperatures in deg F.
      f. Entering-air, wet- and dry-bulb temperatures in deg F.
      g. Leaving-air, wet- and dry-bulb temperatures in deg F.
      h. Water flow rate in gpm (L/s).
      i. Water pressure differential in feet of head or psig.
      j. Entering-water temperature in deg F.
      k. Leaving-water temperature in deg F.

K. 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.
2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

L. 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.

M. Air-Terminal-Device Reports:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Apparatus used for test.
      d. Area served.
      e. Make.
      f. Number from system diagram.
      g. Type and model number.
      h. Size.
      i. Effective area in sq. ft.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Air velocity in fpm.
      c. Preliminary airflow rate as needed in cfm.
      d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

N. 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.

O. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm.
   g. Water pressure differential in feet of head or psig.
   h. Required net positive suction head in feet of head or psig.
   i. Pump 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.

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

3.11 Verification of TAB Report

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

B. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:
   1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
   3. If the second verification also fails, Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.12 Additional Tests

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION
SECTION 23 07 13

DUCT INSULATION

PART 1  GENERAL

1.01  CERTIFICATION/QUALITY ASSURANCE


B. Fire-Test Response Characteristics: Testing in accordance with ASTM E-84. Insulation and related materials, adhesives, coatings, sealers, jackets and tapes, shall have a fire-test response characteristic of: Flame spread rating of 25 or less; Smoke development of 50 or less.

C. Materials shall meet the requirements of NFPA 90-A.

PART 2  PRODUCTS

2.01  DUCTWORK INSULATION

A. Blanket Type Duct Insulation:
   1. Minimum 3/4 pound per cubic foot density, factory-reinforced foil-faced, kraft vapor barrier; with a minimum "R" value of 4.0.
   2. Acceptable manufacturers: Johns-Manville, or Owens Corning.
   3. Use on the following:
      a. Supply and Return - 2" thick.
      b. Reheat coils, including reheat coils at terminal boxes - 1-1/2" thick.
      c. Air flow stations.
      d. Top of supply air diffusers.

E. Board Type Duct Insulation:
   1. Provide minimum 3 pound per cubic foot density semi-rigid, factory-reinforced foil faced Kraft vapor barrier glass fiber board "system" type insulation; having a minimum "R" value of 4.34, unless otherwise specified.
   2. Acceptable manufacturers: Johns-Manville, or Owens Corning.
   3. Use on the following services:
      a. Supply and Return ductwork within Mechanical room - 1-1/2" thick.
      b. Ductwork supply outside air within Mechanical room - 1-1/2" thick
      c. Outside air intake plenums, return air plenums, ductwork and connections to mixing plenums in Mechanical room - 1-1/2" thick.

F. Duct Liner:
   1. Liner: Anti-microbial, 1" thick (unless otherwise indicated on drawings), UL listed, neoprene coated, mat faced, flexible fiberglass of three pounds per cubic foot density. Sizes shown on
the drawings are free area dimensions, after installation of duct liner.

2. Provide liner that complies with UL 181 Erosion Test and has a flame spread rating of 25 or less and a smoke developed rating of 50 or less.
   a. Low pressure supply and return ductwork.
   b. Plenums serving sidewall return and supply grilles.
   c. Plenums serving linear slot diffusers.

**PART 3 \ EXECUTION**

3.01 INSTALLATION – GENERAL

G. Deliver and store insulation materials in manufacturers containers and kept free from dirt, water, chemical and mechanical damage.

H. Complete ductwork pressure testing prior to applying insulation.

I. Apply insulation in workmanlike manner by experienced, qualified, workmen.

J. Surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and before and during application of any finish, unless such finish requires specifically a wetted surface for application.

K. Adhesives, cements and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

L. Stop duct coverings, including jacket and insulation, at fire penetrations of fire or smoke rated partitions, floors above grade and roofs. "Fan-out" or extend jacketed insulation at least 2" beyond angle frames of fire dampers and secure to wall. Maintain vapor barrier.

3.02 BLANKET TYPE DUCT INSULATION

M. Apply jacketed blanket type glass fiber covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel-off" of insulation from jacket to effect a minimum overlap of 2". Staple lap with flare type staples on 1" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as herein before outlined. Cover and seal all staples with Foster 30-80 reinforced with glass cloth. Do not use pressure sensitive tape.

N. Secure jacket to covering using equivalent of Foster No. 85-20 or Childers CP-82 adhesive.

O. For ducts 24" or wider, mechanically fasten insulation to duct bottom, using weld pins having self-locking, metal discs, locating fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.
P. For ducts up to 18" deep, mechanically fasten insulation to duct sides, using one row of pins, plates or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts over 24" deep, apply fasteners as before only using minimum of two rows.

3.03 BOARD TYPE DUCT INSULATION

Q. Apply jacketed board type glass fiber covering to ducts using weld pins having self-locking coated metal or nylon discs; locate fasteners on not over 12" centers laterally and longitudinally. If insulation is grooved to fit around corners, in order to eliminate as many joints as possible, pin as required to hold insulation tight to duct, especially on bottom of duct. Seal pins and joints with Foster 30-80 reinforced with glass cloth.

R. Cover all joints, rips, tears, punctures, disc heads, staples, or breaks in vapor barrier jacket with 4" wide woven glass fabric tape embedded in equivalent of Foster 30-80 vapor barrier, fire resistant adhesive. Do not use pressure sensitive tape.

3.04 PREPARATION

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

3.05 GENERAL INSTALLATION REQUIREMENTS

T. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

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

V. 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.

W. Install insulation with longitudinal seams at top and bottom of horizontal runs.

X. Install multiple layers of insulation with longitudinal and end seams staggered.

Y. Keep insulation materials dry during application and finishing.

Z. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
AA. Install insulation with least number of joints practical.

BB. 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.

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

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

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

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

3.06 PENETRATIONS

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

HH. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Division 07 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

II. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 "Penetration Firestopping."

END OF SECTION
SECTION 23 07 19

HVAC EQUIPMENT AND PIPING INSULATION

PART 1  GENERAL

1.01  SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Chilled-water piping, indoors and outdoors.
   2. Heating hot-water piping, indoors.

B. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Boiler
   2. Chilled Water Pump
   3. Hot Water Heating Pump
   4. Expansion Tanks
   5. Air Separators

1.02  SUBMITTALS

A. Submit manufacturer's product data and installation procedures for review.

PART 2  PRODUCTS

2.01  PIPE AND EQUIPMENT INSULATION MATERIALS

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

B. Cellular Glass (Foamglass): Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Must have a minimum "R" value of 3.4 per inch at 75 degrees F mean temperature. Use Cellular Glass for the following:
   1. Exterior chilled water piping

C. Flexible Tubular Elastomeric:
   1. Provide fire-retardant closed-cell slip-on flexible type; minimum "R" value of 2.57
   2. Acceptable manufacturers: Armacell LLC or AP Armaflex
   3. Use on the following services:
      a. Moisture condensate drains - 1/2" thick
      b. Refrigerant suction and hot gas for split systems: 1" thick.

D. Flexible Sheet:
   1. Provide closed-cell flexible sheet type; minimum "R" value of 3.57
   2. Acceptable manufacturers: Armacell or AP Armaflex
   3. Use on the following services:
a. Chilled water pump casings and flanges: 1" thick
b. Chilled water piping valves, strainers and hydronic specialties: 1" thick
c. Air separators - 1-1/2" thick
d. Refrigeration machine cooler, suction piping and pipe connections: 1-1/2" thick.

E. Fiberglass Pipe Insulation:
2. Use on the following services:
   a. Chilled water piping - 2" and under: 1" thick; 2-1/2" and over: 1-1/2" thick
   b. Heating hot water piping, Runouts to terminal units (12 feet or less) 2" and less - 1/2" thick; 2-1/2" and greater - 1-1/2" thick.
   c. Drain bodies, traps and horizontal drain lines receiving cold condensate - 1/2" thick

2.02 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. For all services, use premolded insulation for pipe fittings, elbows, tees, valves, and couplings matching basic insulation.  Pre-molded insulation fittings shall be equal to those manufactured by Hamf.  Pre-molded insulation fitting shall be finished with glass fabric and vapor barrier mastic.  Glass fiber blanket inserts with plastic cover are not acceptable for pipe fitting insulation.  Field mitering is acceptable for fittings 8" and larger.  Valves, strainers, flanges, etc. shall be covered with mitered insulation segments of the same type and thickness as adjoining pipe insulation.

B. For tanks, heat exchangers and large pipes in systems operating over 60 degrees F when exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored woven glass fabric embedded and finished with Foster GPM mastic.

C. For pipe fittings, valves, strainers, and other irregular surfaces, in chilled water or refrigerant systems operating below 60 degrees F, when inside building or in equipment rooms, cover insulation with white colored woven glass fabric embedded in white vapor barrier coating, Foster 30-35 or equal.

D. All mechanical pipe and fittings within 7'-0" of floors or work surfaces in mechanical rooms and outdoors shall be protected with 0.016" thick smooth, aluminum jacket using factory formed aluminum covers for fittings and valves and secured with self-tapping crews and drawbands.  No corrugated jacket with be allowed.  Install jacket seams on bottom of pipe.
E. For flexible tubular elastomeric pipe and fitting insulation when exposed-to-view inside building or exposed to the weather, finish with two coats of fire retardant self-extinguishing vinyl lacquer type highly flexible coating equivalent to Armstrong "Armaflex Finish", custom color blended to match surrounding surfaces.

**PART 3 EXECUTION**

3.01 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.02 GENERAL INSTALLATION REQUIREMENTS

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

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Adhesives, cements and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during application and finishing.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.
K. 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.

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

M. 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, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

P. 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.

Q. 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.
3.03 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.

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

B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

C. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 "Penetration Firestopping."

3.04 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. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.05 INSTALLATION OF CELLULAR-GLASS INSULATION

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

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut
sections of cellular-glass block insulation of same thickness as pipe insulation.

4. Install jacket material with manufacturer’s recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

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

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of cellular-glass insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as 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.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.08 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. Piping, Exposed:
   1. Aluminum, Smooth: 0.016 inch thick.

3.09 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. Aluminum, Smooth: 0.016 inch thick.

3.10

A. Manual volume damper handles, airflow station pressure ports, access door handles, duct mounted instrumentation shall be left exposed or accessible above the insulation vapor barrier. Damper handles in externally wrapped ductwork shall be provided with stand-off brackets and locking quadrants to ensure the handle can be adjusted without disturbing the insulation vapor barrier.

END OF SECTION
PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

B. Section 019113 – General Commissioning Requirements

C. Section 220800 – Commissioning of Plumbing Systems

D. Section 260800 – Commissioning of Electrical Systems

E. Commissioning Plan, dated [TBD]

1.02 COMMISSIONED SYSTEMS

A. Commissioning is an ongoing process and shall be performed throughout construction. Commissioning verifies that systems are operating in a manner consistent with the Contract Documents.

B. Following is a detailed list of equipment included in each commissioning activity:

1. Building Automation System
2. Rooftop Unit
3. Air-cooled Chiller
4. Chilled Water Pumps
5. VAV Terminal Units

1.03 RESPONSIBILITIES

A. The Contractor shall be responsible for scheduling, supervising and performing start-up, testing and commissioning activities specified in this section and necessary to demonstrate to the Owner successful operation of the commissioned systems.

PART 2 PRODUCTS

2.01 MEANS OF ACCESS
A. The Contractor shall provide means for the CxA to access, observe and visually confirm proper operation of all equipment and systems. These means shall be in compliance with all OSHA and job-site safety regulations.

2.02 Test Equipment

A. The Contractor shall provide the necessary equipment to fully test the commissioned systems as defined in the functional performance test procedures to be provided by the CxA.

PART 3 EXECUTION

3.01 EQUIPMENT CHECKLISTS

A. Equipment checklists, provided by the CxA, shall be completed by the Contractor on CxAAlloy. The following checklists will be provided:

1. Equipment Pre-Functional Checklist

3.02 FUNCTIONAL PERFORMANCE TESTS

A. The Contractor shall provide all documentation as requested to the CxA for development of functional performance testing procedures. This documentation shall include, at a minimum, manufacturer installation, start-up, operation and maintenance procedures. The CxA may request further documentation as necessary for the development of functional performance tests.

B. The Contractor shall review the functional performance test procedures developed by the CxA.

1. The Contractor shall respond in writing to the CxA regarding the acceptability of the proposed test procedures.

2. The Contractor shall note any necessary modifications to the procedures due to the actual equipment/systems or safety concerns and shall submit these to the CxA for consideration.

C. The Contractor shall place equipment and systems into operation and continue the operation as required during each working day of the testing activities.

D. The Contractor shall accomplish the functional performance testing of equipment based on procedures developed by the CxA and as reviewed by the Contractor.

1. The Contractor shall provide skilled technicians to operate the systems during functional performance testing. At a minimum, the contractor should provide one trade technician familiar with the system being tested and one controls technician to operate the system through the BAS.

2. The Contractor shall correct any deficiencies identified during testing and retest equipment as required.
E. Functional performance testing is intended to begin upon completion of a system. Functional performance testing may proceed prior to the completion of the system at the discretion of the CxA and the Contractor.

F. Functional testing shall verify all sequences of operation defined in the Contract Documents for the commissioned equipment and systems.

1. Testing shall occur by overriding setpoints or sensor readings at the BAS or by other means mutually agreed to by the Contractor, the CxA, and the Owner to initiate sequences of operation and verifying the response of the system.

2. Sequences of operation shall be verified under normal power, emergency power, and fire alarm scenarios.

G. Upon successful completion of all functional performance tests, the Contractor(s) shall perform Integrated Systems Testing. The testing shall document and verify the proper response of all Division 23 systems to all potential utility and emergency power operating and failure scenarios.

3.03 TEST AND BALANCE VERIFICATION

A. The Contractor shall provide the labor and test equipment necessary to demonstrate to the CxA that the HVAC air and water systems have been properly balanced.

B. The CxA will randomly select devices, equipment and systems for verification purposes.

1. The Contractor shall be prepared to demonstrate proper balance of at least 10% of non-critical systems. Non-critical systems are those whose sole purpose is to maintain thermal comfort conditions.

C. The Contractor shall regard this verification process as a functional performance test for purposes of time allowed to correct deficiencies and requirements regarding retesting if major problems are discovered.

END OF SECTION
List all sensors associated with this system or unit and verify the calibration, set point and location.

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<th>BAS / Thermostat / Airflow Data</th>
<th>BAS DAT sensor Value F</th>
<th>HW Valve Response Value F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>MAX</td>
<td>Set Point</td>
<td>Reading</td>
</tr>
<tr>
<td></td>
<td>F cfm</td>
<td>F cfm</td>
<td>F cfm</td>
<td>F cfm</td>
</tr>
</tbody>
</table>
PART 1  GENERAL

1.01 DESCRIPTION

A. The Direct Digital Control/Building Automation System (DDC/BAS) shall be Johnson Controls Metasys or approved equal.

B. Provide a complete control system including electrical interlocks, wiring, conduit, relays, switches, control transformers, and all devices required for a complete operational system.

C. The Control Contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters.

1.02 SUBMITTALS

A. Product Data: For each type of product include the following:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   4. Installation, operation and maintenance instructions including factors effecting performance.
   5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
   6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
   7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.
   8. Schematic drawings for each controlled HVAC system indicating the following:
      a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
      b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
      c. A graphic showing location of control I/O in proper relationship to HVAC system.

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East Tennessee State University  RP2  DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

B. System Description:
1. Full description of the existing DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend available for format and timing and events which initiate generation.
3. Design Submittal Schedule and design calculations for control valves and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure-differential drop across valve at Project design flow condition.
   c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
   d. Design and minimum control valve coefficient with corresponding valve position.
   e. Maximum close-off pressure.
   f. Leakage flow at maximum system pressure differential.
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

C. Product Certificates:
1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include operation and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
   b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
g. List of recommended spare parts with part numbers and suppliers.
h. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
i. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
j. Licenses, guarantees, and warranty documents.
k. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
l. Owner training materials.

1.04 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified 12 month warranty period.
1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: One year from date of Substantial Completion.
5. Replacing defective parts and components as required.

PART 2       PRODUCTS

2.01 DDC SYSTEM DESCRIPTION

A. Direct Digital Control/Building Automation Systems (DDC/BAS) shall be fully compatible with ETSU College of Medicine Campus Standard automation system and shall be Johnson Controls Metasys.
B. Web based, building automation system (BAS) incorporating direct digital control (DDC), energy management, and equipment monitoring and control.

2.02 NETWORK AUTOMATION ENGINES (NAE)

A. Network Automation Engine (NAE 45XX)
   1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
   2. Automation network - The NAE shall reside on the automation network and shall support a subnet of system controllers.
   3. User Interface - Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
      a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
      b. The NAE shall support a minimum of two (2) concurrent users.
      c. The web based user shall have the capability to access all system data through one NAE.
      d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
      e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
      f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
      g. Systems that support UI Graphics from a central database or required the graphics to reside on the user's personal computer are not acceptable.
      h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
         1) Configuration
         2) Commissioning
         3) Data Archiving
         4) Monitoring
         5) Commanding
         6) System Diagnostics
      i. Systems that require workstation software or modified web browsers are not acceptable.
      j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
   4. Processor - The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital processor. Standard operating
systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

5. Memory - Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

6. Hardware Real Time Clock - The NAE shall include an integrated, hardware-Based, real-time clock.

7. The NAE shall include troubleshooting LED indicators to identify the following conditions:
   a. Power - On/Off
   b. Ethernet Traffic - Ethernet Traffic/No Ethernet Traffic
   c. Ethernet Connection Speed - 10 Mbps/100 Mbps
   d. FC Bus - Normal Communications/No Field Communications
   e. Peer Communication - Data Traffic Between NAE Devices
   f. Run - NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
   g. Bat Fault - Battery Defective, Data Protection Battery Not Installed
   h. Fault - General Fault
   i. Modem RX - NAE Modem Receiving Data
   j. Modem TX - NAE Modem Transmitting Data

8. Communications Ports - The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
   a. USC port
   b. URS-232 serial data communication port
   c. RS-485 port
   d. Ethernet port

9. Diagnostics - The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

10. Power Failure - In the event of the loss of normal power, the NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
   a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
   b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification - The NAE shall be listed by Underwriters Laboratories (UL).

12. Controller network - the NAE shall support the following communication protocols on the controller network:
The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

1) A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

2) The Conformance Statements shall be submitted 10 days prior to bidding.

3) The NAE shall support a minimum of 50 control devices.

b. The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT 10.

1) All LonWorks controls devices shall be LonMark certified.

2) The NAE shall support a minimum of 64 LonWorks enabled control devices.

c. The NAE shall support the Johnson Controls N2 Field Bus.

1) The NAE shall support a minimum of 50 N2 control devices.

2) The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.

3) The Bus shall employ a master/slave protocol where the NAE is the master.

4) The Bus shall employ a four (4) level priority system for polling frequency.

5) The Bus shall be optically isolated from the NAE.

6) The Bus shall support the Metasys Integrator System.

2.03 STAND-ALONG DDC PANELS

A. General: Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. Each DDC panel shall operate independently be performing its own specified control, alarm management operator I/O and historical data collection.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases.

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts

2. Digital Outputs for on/off equipment control

3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements

4. Analog Outputs for valve and damper position control, and capacity control of primary equipment

5. Pulse Inputs for pulsed contact monitoring
D. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment.

E. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

F. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

2.04 PERSONAL COMPUTER OPERATOR WORKSTATION (FACILITY OFFICE)

A. General: Provide an operator's workstation to access the BAS network.

B. Provide PC Compatible computer system configured for use with DDC system, Dell Inc. or approved equal with the following minimum features:
   1. Quad Core Intel® Core™ i7 920 processor
   2. 4.0 GB RAM memory
   3. 320 GB hard disk
   4. USB ports built-in
   5. DVD +/- RW 1-8X minimum CD-RV
   6. 22" LCD flat panel color monitor
   7. Microsoft USB mouse
   8. Microsoft Keyboard
   9. Software: Windows 7 Professional

C. Provide a color ink jet, multi-function, wireless printer, copier, fax and scanner equal to Lexmark S600. Printer shall print alarms, graphics and any other screen displays.

D. Network Connection: Graphical workstations shall allow for access to the BAS network through a pull-down menu approach using only a mouse. The keyboard shall be required only when entering text of for programming functions. The workstation shall be used as an interface to the BAS network and shall not be required to process any control or energy management algorithms nor manage any BAS network communications.

E. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.
F. Multiple user security levels shall be provided to allow for various degrees of system access and control. The system shall automatically generate a report of log-on/log-off time and system activity for each user. Provide automatic log-off capability to prevent unauthorized system use.

G. The Workstation shall be provided with a key element display that records log-ons, log-offs, overrides, alarms and alarm acknowledgments.

2.05 SENSORS

A. BAS Sensors:
   1. Provide sensors, controls, instruments, and control interfaces to meet the performance specified herein. Sensors shall be high quality precision electronic type, selected to be compatible with the BAS controllers and appropriate for the service specified herein. Accuracy values specified herein include sensor, wiring, signal conditioning and display accuracies for overall end-to-end performance. Sensors shall be selected to place the expected value in the middle third of the device's range.

   2. Temperature sensors: 100 or 1000 ohm nickel resistance temperature device (RTD), Deutsche Industrial Norms (DIN) 43760, with an average percent change in resistance per degree (α) of 0.00385± 0.00002 ohms/ohm/°C, selected for normal range of media sensed with accuracy of ±0.5°F at 70°F except chilled water sensors used for Btu calculations shall have an accuracy of ±0.25°F at 32°F. Sensors used for Btu calculations shall be matched pairs at the calibration point. Temperature sensor stability errors shall not exceed 0.25°F cumulative over a 5 year period. Provide thermowells and insertion type sensors for water temperature sensing. Air temperature sensing shall be provided by duct insertion type sensors for supply or return duct temperatures and by extended element averaging type for plenum, and coil entering or leaving temperatures. RTD transmitters shall be a 2-wire, loop-powered device, producing a linear 4-20 mA output corresponding to the temperature span of the connected sensor. The output error shall not exceed 0.1% of calibrated span. Transmitters shall include noninteracting offset and span adjustments and RFI shielding and rejection circuitry to prevent disruption from ambient signals. Transmitter drift shall be less than 0.1°F per year.

   3. Space temperature sensors: space temperature type with setpoint adjustment range of 45°F to 85°F. the setpoint adjustment shall be locked out, overridden, or limited as to time or temperature in software from a central or remote operator's terminal. Precisions thermistors may be used in space temperature sensing applications below 200°F. Sensor accuracy over the application range shall be minimum 0.5°F between the range of 32°F to 150°F including sensor error and A/D conversion resolution error. Sensor manufacturer shall utilize 100% screening to verify accuracy. Thermistors shall be pre-aged and inherently stable. Stability error of the thermistor over 5 years shall not exceed 0.25°F cumulative. Sensor element and leads
shall be encapsulated. Bead thermistors shall not be used. Space temperature sensors shall include a communications port for local connection of a portable test/terminal device for communications/programming access to the associated BCS controller.

a. Covers:
   1) Space temperature sensors shall have cover, visible temperature indicator integral to the sensor, and accessible means of setpoint adjustment.

4. Humidity sensors: bulk polymer type, with self-contained 4-20 mA transmitter and replaceable element. Accuracy shall be ±2% RH in the range of 20% to 90%. The transmitter shall include noninteracting zero and span adjustments with an output error not exceeding 0.1% of calibrated span. Saturation shall not alter calibration. Sensors for space humidity shall have same appearance as space temperature sensors.

5. Pressure transmitters: 2-wire strain gauge type, designed for media sensed for static pressure or differential pressure. The span shall be continuously adjustable from 0% to 125% of the expected full pressure of full flow differential pressure. The zero shall be continuously adjustable on outputs. Transmitters shall product a 4-20 mA signal with an accuracy of ±1.0% of the upper range limit for 6 months from calibration. Instruments shall be capable of withstanding an overrange pressure limit of 300 normal.

6. Current sensing relays: current sensing relays shall provide an adjustable setpoint normally open contact rated at a minimum of 50 V peak and 0.5 A or 25 VA, noninductive. There shall be a single opening for passage of current carrying conductors. Relays shall be sized for operation at 50% rated current based on the connected load. Voltage isolation shall be a minimum of 600 V.

7. Filter status: filter status shall be sensed by digital pressure differential switches.

8. CO2 sensors: dual channel infrared type, with 10 micron filter to prevent particulate contamination of sensing element. Sensor shall have an accuracy of ±5% of reading up to 10000 ppm, with a repeatability of ±20 ppm and a maximum drift of ±10 ppm per year, and a recommended calibration interval of 5 years. Sensor shall have a response time of no more than 2 minutes to a 90% of full scale change. Sensor and transmitter shall provide a 4-20 mA analog output proportional to gas concentration.

2.06 MATERIALS

A. Actuators:
   1. BAS terminal unit actuators: 24 V nonstall type, providing complete modulating control for the full range of damper movement. Actuators shall be de-energized when the damper has reached the operator or system determined position. Actuators shall be supplied to the terminal unit manufacturer for factory mounting and calibration. Actuators shall be removable for servicing without removing the terminal unit. Actuators shall be
provided with transformers for proper operation from the terminal unit controller power source.

2. Other actuators: 24 V electric worm-gear type; sized to provide required starting torque and to control the drive apparatus smoothly. Higher voltage actuators are acceptable for specific applications where 24 V actuators are not adequate. Actuators shall have spring return.

B. Control valves: 2" and smaller, globe ball type with bronze bodies and screwed connections; over 2", globe type with cast iron bodies and flanged connections.
   1. Valves shall be capable of full closure against 150% of design pump head, or a 50 psig differential pressure, whichever is greater.
   2. Valves for water shall have equal percentage flow characteristics. Modulating control valves shall be sized for a pressure drop of 3 psig to 5psig, unless indicated otherwise on the Drawings. Two-position valves shall be in line size.
   3. Valves for steam shall have linear flow characteristics. Steam valve sizes are indicated on the Drawings.
   4. Pressure/temperature rating: as specified in Section 23 10 00, "Piping, Valves and Accessories".
   5. At the Contractor's option, control valves may be butterfly type for chilled and condenser water service in piping 8" and larger. Modulating butterfly valves shall be sized for full flow pressure drop of 2psig to 4 psig at 60% open and be limited to this opening. Two-position butterfly valves shall be line size. Valves shall be rated for bubbletight closure at a differential pressure equal to the valve body rating.

C. Control dampers: single-blade up to 8" high, multiblade over 8" high; minimum 80% free area based on damper frame outside dimensions.
   1. Blades: minimum 16 gauge galvanized steel, or extruded aluminum. Blades shall be airfoil shape.
      a. Pivot rods: steel, minimum 0.5" diameter or hex, with one rod extended 6" to permit operation of damper from outside the duct.
      b. Maximum length 42", maximum width 8".
      c. At points of contact: interlocking or overlapping edges, and compressible neoprene or extruded vinyl blade seals, and compressible metal side seals designed for temperature -40°F to 180°F at leakage rates specified herein.
      d. Type:
         1) Opposed blade: for balancing and modulating applications.
         2) Parallel blade: for 2-position, and outside and return air mixing applications. For mixing applications, orient dampers to achieve maximum mixing at throttled conditions.
      e. Maximum damper area per motor: 15ft².
1. Leakage when closed: less than 4 cfm/ft² at 1" wg differential static pressure based on a 48" damper width.
2. Frames: galvanized steel bar minimum 2" wide x 12 gauge for dampers 10" high or less, and 3.5" x 0.875", 16 gauge galvanized roll-formed channel with double-thickness edges or 5" x 1" x 0.125" extruded aluminum channel for 11" high and larger.
   a. Corner bracing.
   b. Full size of duct or opening in which installed.
   a. Thrust bearings: vertically mounted.
   b. Maximum spacing: 42".
4. Finish on steel parts: galvanized.
5. Operating linkage: factory-assembled, concealed in frame out of airstream, steel construction.

D. Panels: Surface type cabinet with hinged front panel and cylinder lock. Panels shall utilize one master key.

E. Thermowells: monel, brass, or copper for use in water piping and stainless steel for other applications. Thermowells shall have threaded plug and chain, retaining nut, and lagging neck to clear insulation. Inside diameter of insertion neck shall accommodate the element being installed.

F. Weather shield enclosures: NEMA 3R rated with transparent cover, sized for the device enclosed.

G. Airflow measurement systems: provide complete UL listed assemblies to monitor airflow in ductwork at locations indicated on the Drawings. Each system shall be complete with one or more multipoint measuring probes, airflow sensors and a single microprocessor-based transmitter.
   1. Probes: Aluminum or stainless steel construction with mounting brackets. Probes shall be supported at both ends.
   2. Airflow sensors: Designed to operate at velocities of 50 fpm to 5000 fpm, temperatures of -20°F to 140°F, and relative humidities of 0% to 99% (noncondensing). Each sensing point shall independently determine the airflow rate which shall be equally weighted and averaged by the transmitter prior to output.
   3. The minimum number of sensors for each assembly shall be as follows:

<table>
<thead>
<tr>
<th>Area, (ft²)</th>
<th>No. of Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 4</td>
<td>4</td>
</tr>
<tr>
<td>4 to 8</td>
<td>6</td>
</tr>
<tr>
<td>8 to 12</td>
<td>8</td>
</tr>
<tr>
<td>12 to 16</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 16</td>
<td>16</td>
</tr>
</tbody>
</table>

4. Transmitters: Designed to operate at temperatures of -20°F to 120°F and provided with LCD display 24 V AC power connection, and analog output signal (0-10 V DC or 4-20 mA) for connection to the BCS.
5. Accuracy: ±2% of reading over the entire operating airflow range.

2.07 ELECTRONIC AND ELECTRIC CONTROL COMPONENTS

A. Electric Thermostats: Thermostats to be manufacturer's best commercial grade thermostat with adjustable setpoint, dials calibrated in degrees F. Select thermostats with suitable range for service intended. Provide each thermostat with locking metal cover. Thermostat shall be equal to Johnson Controls TE-67NP-2N00.

B. Electronic Sensors/Transmitters: Sensors/transmitters to be 1000 Ohm platinum RTD type with high resistance change vs. temperature or humidity change, accurate to +/- 0.3 degrees F for temperature and +/- 2.0% for humidity at applicable range, and provide 4 to 20 MA or 0 to 5 VDC output signal. Sensors/transmitters to be suitable for room, duct, or well mounting as required by application. Room type to have built-in setpoint potentiometer and digital room temperature/humidity indication. Select for temperature/humidity range of application. Provide appropriate mounting plate and hardware. Temperature sensors used as a part of Energy (BTU) Measurement System shall meet the applicable requirements of that section.

C. Freezestats (Low Limit Binary Type): Provide single, custom length Freon-filled capillary tube type with sensing element actuated by temperature on any one foot portion. Sensor shall be a single element with length of one linear foot for every one square foot of coil face area. Freezestats to be UL approved, manual reset type.

D. Control Panels: Control panels to be constructed of unitized steel or aluminum cabinets. Provide cabinets with hinged, locking door opening to the front. Multiple panels mounted side-by-side to be hinged to the left or on opposite sides to open in the middle. Start-stop switches, hand-off-automatic switches, pilot lights, and temperature indicating devices to be flush-mounted in panel door. All other devices to be internally mounted within panel. Local panels exposed to weather to be weatherproof construction. Panel locations to be approved by Designer and be accessible for operation and maintenance. All lines in panel shall have number I.D. bands. All devices inside the panel or mounted on panel face shall have an engraved laminated plastic nameplate. Wiring within panel to conform to National Electrical Code, and shall be neatly bundled and laced or enclosed in panduit trough.

E. Transformers: Provide all 24-volt control transformers necessary to convert 120-volt line voltage power to control voltage at control devices.

F. Relays, Hand-Off-Auto Switches, Pilot Lights: Provide all relays, hand-off-auto switches, and pilot lights necessary to accomplish automatic control of the mechanical systems. See electrical drawings for starters provided integral with hand-off-autos, pilot lights, and auxiliary contacts.
G. Pressure Switches: Pressure switches shall have contact action and pole configuration as required by application, U.L. listing, and adjustable setpoint.

2.08 AIR FLOW MEASURING STATION

A. Multi-point electronic thermistor probe suitable for duct or fan inlet airflow measurement with transmitter, equal to Ebtron Advantage II Gold Series. Provide aluminum alloy casing, ± 2% / ± .25% accuracy/repeatability and UL listed transmitter.

2.09 PRESSURE TRANSMITTERS/TRANSDUCERS:

A. Acceptable Manufacturers:
   1. Setra Systems, Inc.

B. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   1. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   2. Output: 4 to 20 mA.
   3. Building Static-Pressure Range: 0- to 0.25-inch wg.
   4. Duct Static-Pressure Range: 0- to 5-inch wg.

C. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

D. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and testing to 300-psig; linear output 4 to 20 mA.

E. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

F. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.10 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each stand-alone DDC controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases.
D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable operator's terminal connected to any DDC panel in the network.

E. Application specific controllers shall directly support the temporary use of a portable service terminal.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. The modes of operation supported by each ASC shall minimally include, but not be limited to, the following:
   1. Daily/Weekly Schedules
   2. Occupancy Mode
   3. Economy Mode
   4. Temporary override Mode

H. Continuous Zone Temperature Histories: Each ASC shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

I. Alarm Management: Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

J. Application Descriptions: 
   1. VAV Terminal Unit Controllers:
      a. VAV terminal unit controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion.
         1) Single Duct (Cooling Only or Cooling With Reheat)
      b. VAV terminal unit controllers shall support the following types of point inputs and outputs:
         1) Proportional Cooling Outputs
         2) Heating Outputs
      c. Each VAV terminal unit shall be provided with a thermostat with numerical temperature setpoint adjustment with scales graduated in degrees F.
   2. AHU Controllers:
      a. AHU controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.
      b. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation.
2.11 DDC CONTROLLERS

A. The DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:
   1. Controller hardware shall be suitable for the anticipated ambient conditions.

F. Power and Noise Immunity:
   1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
   2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:
   1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
      a. Network Controllers: 50 percent.
      b. Programmable Application Controllers: Not less than 60 percent.
      c. Application-Specific Controllers: Not less than 80 percent.
   2. Memory shall support DDC controller’s operating system and database and shall include the following:
      a. Monitoring and control.
      b. Energy management, operation and optimization applications.
      c. Alarm management.
      d. Historical trend data of all connected I/O points.
      e. Maintenance applications.
      f. Operator interfaces.
      g. Monitoring of manual overrides.

H. Input and Output Point Interface:
   1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

2.12 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:
   1. Include adequate number of controllers to achieve performance indicated.
   2. Controller shall have enough memory to support its operating system, database, and programming requirements.
   3. Data shall be shared between networked controllers and other network devices.
   4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   5. Controllers that perform scheduling shall have a real-time clock.
   6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
   7. Controllers shall be fully programmable.

B. Communication:
   1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:
   1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:
   1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
   2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
   3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.13 DYNAMIC COLOR GRAPHICS

A. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.

B. The graphics applications shall include a create/edit function and runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
C. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

D. Graphics runtime functions - A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
   1. All graphics shall be fully scalable.
   2. The graphics shall support a maintained aspect ratio.
   3. Multiple fonts shall be supported.
   4. Unique background shall be assignable on a per graphic basis.
   5. The color of all animations and values on displays shall indicate if the status of the object attribute.

E. Operation from graphics - It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device.

F. Graphic editing tool - A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
   1. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
   2. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.

G. Aliasing - Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

2.14 ELECTRICAL POWER DEVICES

A. Transformers:
   1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
   2. Transformer shall be at least 40 VA.
   3. Transformer shall have both primary and secondary fuses.

B. DC Power Supply:
   1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
   2. Enclose circuitry in a housing.
   3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
   4. Performance:
a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.
d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

**PART 3 EXECUTION**

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
3.02 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, cabinets, building wire and cable according to Division 26.
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   4. Number-code and color-code conductors for future identification and service of control system, except local individual room control cables.
   5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

3.03 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Prepare and submit closeout submittals when no deficiencies are reported.

E. A part of DDC system final review shall include a demonstration to parties participating in final review.
   1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
   2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
   3. Demonstration shall include, but not be limited to, the following:
      a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be
selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

b. HVAC equipment and system hardwired and software
safeties and life-safety functions are operating according to sequence of operation. Up to 20 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Each Programmable Application Controller:
   1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
   2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and PDA. Show that
maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

4) Electric Power: Ability to disconnect any controller safely from its power source.

5) Wiring Labels: Match control drawings.

6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

For Existing Operator Workstation:
1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

3.04 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:
1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.

C. Minimum Training Requirements: Provide not less than one day of training.

D. Training Schedule:
1. Training shall occur within normal business hours at a mutually agreed on time.

D. 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.

END OF SECTION
SECTION 23 21 13

HYDRONIC PIPING

PART 1  GENERAL

1.01  GENERAL

A.  Submit pipe and fitting. Work shall not start until approval. Pipe, fittings, weights, working pressure and classification shall be clearly marked.

PART 2  PRODUCTS

2.01  COPPER TUBE AND FITTINGS

A.  Hard-Drawn Seamless Copper Tubing: ASTM B 88, Type L (ASTM B 88M). Elbows are to be long radius pattern. Solder shall be 95-5 type. "Tee pullers" shall not be used in place of tees on copper piping.
   1.  Heating hot water supply and return piping 2" and smaller.
   2.  Chilled water supply and return piping 2" and smaller.

B.  Copper Pipe Fittings: ASTM B-62, dimensions conforming to ANSI B16.22, wrought copper, with sweep patterns for copper tubing. Provide dielectric couplers at junction of steel pipe and copper piping systems.

C.  DWV Copper Tubing: ASTM B 306, Type DWV for above ground moisture condensate drain piping.

D.  Unions to be brass ground joint, 250-pound working pressure.

E.  Nipples used in conjunction with copper pipe to be brass.

2.02  STEEL PIPE AND FITTINGS

A.  Steel Pipe: ASTM A-53, black steel, Schedule 40 with welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
   1.  Heating hot water supply and return piping 2-1/2" and larger.
   2.  Chilled water supply and return piping 2-1/2" and larger.

B.  Piping 2-1/2" and larger shall be seamless black steel, Schedule 40, ASTM A-53, Gr. B, or A106 with welded or flanged fittings, ANSI B16.9. ERW piping may be considered. Elbows are to be long radius pattern. Field-fabricated fittings are not acceptable. Forged steel, gasketed flanges, ANSI B16.5, of the welded neck type are to be used at flanged connections. Slip-on type may be used on straight pipe. Flanges must be compatible with valve and equipment connections. Where a branch connection from a main or header is one half the main diameter or smaller, saddle-type, forged steel welding fittings may be used.
C. Welding shall conform to ANSI Code for Pressure Piping, Section B31.1. All welds shall be of the single "V" butt joint type with optimum fusions and 100% weld penetration of wall thickness. Piping should be welded by the shielded arc type electrode-electric arc process. Butt joints should be made with split backing rings. In most cases, direct welded connections shall not be made to valves, strainers, equipment, etc. The contractor should be required to obtain certification of all pipe welders on the project, in accordance with Section IX of the ASME code.

D. Union or flanged connections should be provided at valves, equipment, etc. Provide dielectric unions at the junction of steel pipe and equipment with copper piping systems. Or, preferably, provide steel to brass to copper connections. Where size changes on horizontal lines, use reducing fittings having eccentricity down, top level. All piping take-offs should be made from the top of mains or headers. Do not "bullhead" tee connections.

2.03 DIELECTRIC FITTINGS

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

PART 3 EXECUTION

3.01 PIPING APPLICATIONS

A. Makeup-water piping shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

B. Makeup-Water Piping Installed Belowground and within Slabs: Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

C. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

E. Air-Vent Piping:
   1. Provide manual air vents at high points of vertical risers and at each water coil.
   2. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
   3. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.
F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.02 PIPING INSTALLATIONS

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

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

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using 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 Section 232116.
Q. Install unions in piping, 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

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

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves, Escutcheons and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves, Escutcheons and Sleeve Seals for HVAC Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230517 "Sleeves, Escutcheons and Sleeve Seals for HVAC Piping."

X. Do not use bullhead tees.

3.03 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for 2-1/2 to NPS 4: Use dielectric flange kits.

D. Dielectric Fittings for 6 and Larger: Use dielectric flange kits.

3.04 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. 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.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. 3/4: Maximum span, 7 feet.
   2. 1: Maximum span, 7 feet.
   3. 1-1/2: Maximum span, 9 feet.
   4. 2: Maximum span, 10 feet.
   5. 2-1/2: Maximum span, 11 feet.
   6. 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   6. 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   7. 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at each floor.

3.05 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

H. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections. Reference floor plans for pipe sizes.

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.

3.07 WATER DRAINING

A. Provide 3/4" hose end gate valves at low points and bottom of each riser to drain HVAC water systems.

3.08 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.

3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.

2. Inspect pumps for proper rotation.

3. Set makeup pressure-reducing valves for required system pressure.

4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).

5. Set temperature controls so all coils are calling for full flow.

6. Inspect and set operating temperatures of hydronic equipment, such as chillers and heat exchangers to specified values.

7. Verify lubrication of motors and bearings.

END OF SECTION
SECTION 23 21 14

EXTERIOR AND UNDERGROUND CHILLED WATER DISTRIBUTION SYSTEMS

PART 1  GENERAL

1.01  APPLICABLE STANDARDS:
The standards listed herein by society name, codes, etc. form a part of this specification to the extent referenced. The publications of such references are referred to in the text by the basic designation only, i.e., ASTM, ASME, etc.

1.02  SCOPE:
Provide a completely operational prefabricated and pre-insulated underground distribution system for chilled water supply and return as shown on the drawings and specified herein. The work shall include but not be limited to the following:

A.  The Contractor shall be responsible for field verification and site surveying required for determining exact dimensions for ordering materials and completing the installation.

B.  Submittal of technical product data, installation instructions, certifications and shop drawings as required herein.

C.  Manufacture of the system in strict accordance with quality control and testing requirements as specified herein.

D.  Shipment, handling, storage and installation of the system in strict accordance with manufacturers’ instructions and requirements as specified herein.

E.  Coordination with all other trades in the installation of this and other work associated with the project.

F.  Provision of accessories, valves, specialties, seals, materials, labor and equipment required for a complete and operational system installation in accordance with Contract.

G.  Testing, repair or replacement of defective materials or work, retesting to meet the test requirements of this section.

H.  Excavation, dewatering, shoring, backfill and compaction as specified herein, and in accordance with manufacturers’ instructions and job site requirements.
1.03 APPROVED MANUFACTURERS:
Basis of design is Rovanco Insul-8 steel carrier pipe with HDPE jacket.

A. Alternate approved manufacturer is Perma-Pipe XTRU- Therm. All requirements specified herein must be met by the system provided.

B. Substitutions of insulation materials, jacket materials, carrier pipe types and schedules shall not be permitted. Changes in pipe routing shown on the drawings shall not be permitted. Specified insulation thickness and jacket thicknesses shall be minimum permitted.

C. Only systems meeting the requirements of this section and listed under approved manufacturer’s paragraph will be accepted.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer’s technical product data, installation instructions and details, and Field Service Technician’s qualifications.

B. Shop Drawings: Submit scaled layout drawings of the systems, including details of all components, fittings, expansion/contraction compensation, end seals, and anchors. Drawings shall clearly indicate pipe sizes, jacket sizes, slopes of horizontal runs, trench cross section details, and wall or floor penetration details. All dimensions shall be field verified prior to manufacturer of the system.

C. Record Drawings: Included installation details in the project Record Drawings upon completion of installation. Record Drawings shall reflect actual installed conditions of the systems in plan and elevations and shall accurately locate all system components.

D. Maintenance Data: Submit maintenance data for systems provided. Included this date with product, shop drawings, record drawings in an Owner’s maintenance manual.

PART 2 PRODUCTS

2.01 GENERAL:
The underground chilled water distribution system shall be a factory prefabricated and pre-insulated system consisting of carrier pipe, insulation and jacketing as specified, and supplied by an approved manufacturer listed herein.
2.02 System shall be designed for working pressures up to 150 psig and working temperature of 40° F, and shall meet the following requirements:

A. Carrier pipes shall be black steel, ASTM A53, Grade B, seamless, schedule 40 for sizes through 10” diameter; 0.375 inch wall thickness for sizes 12” and larger diameter.

B. Carrier pipe fittings shall be wrought steel, weld type, long radius, and shall match thickness of adjacent pipe. For pipe sizes less than 2.5” diameter, fittings shall be socket welded. For pipe sizes 2.5” and larger fittings shall be butt welded.

C. Insulation for pipe and fittings shall be polyurethane foam with the following characteristics: K factor of not greater than .15 at 50 degree F ambient temperature, minimum density of not less than 2 pounds per cubic foot, in conformance with MIL-I-24172, completely filling the annular space between carrier pipe and jacketing. Minimum insulation thickness will be in accordance with the following table.

D. Jacketing for all pipe and fittings shall be seamless, high density polyethylene (HDPE), conforming to ASTM D1248 and D3350, type III, category 5, Class C and grade P23/P34. Minimum jacket thicknesses and diameters shall be in accordance with the following schedule:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>INSULATION THICKNESS</th>
<th>JACKET THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 in. and below</td>
<td>1.0 in.</td>
<td>.125 in.</td>
</tr>
<tr>
<td>6 in. thru 10 in.</td>
<td>2.0 in.</td>
<td>.150 in.</td>
</tr>
<tr>
<td>12 in thru 18 in.</td>
<td>2.0 in.</td>
<td>.200 in.</td>
</tr>
</tbody>
</table>

E. All fittings shall be factory prefabricated and pre-insulated at manufacturers’ plant. No insulation of fittings will be allowed on the job site. All factory fabricated jacket joints and miters for elbows, tees, anchors and accessories shall be HDPE butt fusion welded. The factory HDPE welding procedure and quality control method shall be submitted with product data submittals for approval.

F. After welding and testing of carrier pipes, field joint area shall be insulated with sectional urethane foam. No mixing, pouring or spraying of foam insulation shall be allowed at field joints. Sectional urethane foam insulated field joint shall be covered with a split HDPE rock shield of same thickness as adjacent jackets and the entire joint area covered with a polyethylene heat shrink cover, minimum 60 mils thickness.
G. End seals will be provided at all terminations of the pre-insulated system. End seals shall be pre-molded polyethylene shrink type.

**PART 3 EXECUTION**

3.01 GENERAL:
Installation of the prefabricated, pre-insulated systems shall be done in accordance with the following requirements and the manufacturer’s instructions.

3.02 EARTHWORK
A. Provide excavation, dewatering, backfilling, and shoring under this section. Comply with all local codes and safety ordinances related to this work.

B. Excavate trenches to the depths as indicated on the drawings, making allowance for 6” of bedding material. Grade the bottom of the trench to provide uniform beaming and support for the pipe. Remove shoring, bracing, support blocks and debris from the trench. Install a 6” layer of sand bedding material and hand compact to 90% modified proctor.

C. After placement of pipe back fill with sand or an approved sand-gravel mixture in 6” lifts to a distance of 12” above the top of the pipe casting or jacket. Hand compact each layer.

D. Place final backfill in one foot lifts. Final backfill material to be clean earth free of organic material, rocks, and foreign matter. Final backfill may be compacted using mechanical compaction equipment to 85% modified proctor.

E. Maintain minimum cover of 24” above top of pipe casting in grassed areas and 36” in paved areas and below sidewalks.

3.03 RECONDITIONING SURFACES

A. Unpaved surfaces shall be restored to their original condition and elevation. Sod or topsoil shall be carefully preserved and replaced after backfilling. Sod that is damaged shall be replaced.

B. Paved surfaces, sidewalks, gutters and curbs shall be patched or restored to an undisturbed condition.

3.04 WELDING:
The contractor shall be solely and entirely responsible for the quality of system welding.
A. Qualification of welders, rules of procedure for qualification, and general requirements for fusion welding shall conform to applicable portions of ANSI 31.1 and AWS B3.0. All welds shall have 100% penetration. Each welder shall be examined at the job site by the Contractor to determine the ability of the welder to meet the qualifications required. The Contractor shall have available for review a listing of qualified welder’s names and corresponding code markings.

B. Field beveling and factory beveling may be by mechanical means or flame cut. For flame cut bevels, thoroughly clean surfaces of scale and oxidation just prior to welding. All beveling shall conform to ANSI B31.1 and AWS B3.0.

C. Use split welding rings for field joints on all pipe 2.5” and larger to assure proper alignment, complete penetration, and prevention of weld splatter reaching the interior of pipe. Make field joints for pipe less than 2.5” using welding sockets.

D. Test all welds in accordance with provisions of this section. Replace and re-inspect defective welds. Repairing defective welds by adding weld material over defect or by peening shall not be permitted.

E. Store electrodes in a heated dry area and keep free from moisture during fabrication operations.

F. For factory fabrications, all steel pipe and fittings shall be welded and tested in accordance with ANSI B31.1 Code for Pressure Piping. All steel pipe welders at the prefabrication plant shall be certified. Steel pipe welding procedures and certifications of welders are to be submitted with product data submittals.

3.05 TESTING

A. Carrier pipes shall be hydrostatically tested at 1.5 times working pressures or at 150 psig, whichever is greater, for a period of four hours. Visually inspect all joints for signs of leakage. Systems may be tested in stages, but every weld joint shall be tested.

B. Additionally, where piping crosses traffic thoroughfares and other areas subject to frequent vehicular or equipment loads, perform radiography for all field welds.

C. Designer shall be notified 48 hours prior to any test. Contractor shall submit test reports on every test indicating date of test, sections tested,
beginning and ending times and beginning and ending pressures recorded.

END OF SECTION
SECTION 23 21 16

HYDRONIC PIPING, VALVES, AND SPECIALTIES

PART 1 GENERAL

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: 125 psig at 200 deg F.
2. Chilled-Water Piping: 125 psig at 200 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Air-Vent Piping: 200 deg F.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 VALVES

A. Ball Valves
1. HVAC Circulating Water Piping: 2" and less Figure T-585-70 or S-585-70, 2-piece, full port, 600 psi, WOG, TFE seats.
2. Provide ball valves with locking handle.
3. Provide extended lever for insulated service.
4. Stainless Steel balls to be used.

B. Butterfly Valves - 2-1/2" And Up:
1. HVAC Circulating Water Piping: Figure LD-2000, lug type, 200 psi, Class 125, EPDM liner, aluminum bronze disc.
2. Butterfly valves rated bubble tight for dead end service at full pressure in both directions without the need for downstream blind flange.
3. Provide hand wheel and closed housing worm gear on valves 8 inches and larger. Provide clamp lock hand lever operators on valves less than 8 inches.

C. Check Valves:
1. HVAC Circulating Water Piping: System pressures 125 psi and less: Figure 910, non slam.

D. Control Valves:
1. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230923 "Direct Digital Control (DDC) System for HVAC.

E. Balancing Valves: Bronze, Calibrated-Orifice
1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

F. Pressure-Reducing Valves: ASME labeled, Diaphragm-Operated
2. Disc: Glass and carbon-filled PTFE.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Diaphragm-Operated Safety Valves: ASME labeled.
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
5. Diaphragm: EPT.
7. Inlet Strainer: Stainless steel, removable without system shutdown.
9. 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.

H. Flow Balancing Valve
1. Type: Similar to B & G "Circuit Sentry", Armstrong "CBV" or Taco "AccuFlow".
2. Provide calibrated, non-ferrous valve with provisions for connecting a portable differential pressure meter for flow measurement and balance.
3. Provide meter connections with built-in check valves.
4. Provide integral pointer to register degree of valve opening with tamper proof memory feature.
5. Provide valve with drain connection.
6. Construct valve with integral seals to prevent leakage around rotating element.
7. Construct valve for 125 psi working pressure at 150 degrees F.
8. Provide preformed polyurethane insulation for easy access to valve without disturbing field applied adjacent insulation.
9. Provide valve with engraved tag attached indicating design flow, pressure, and flow characteristic of station.

2.03 ELECTROMAGNETIC FLOW METER
A. Insertion style electromagnetic flow meter equal to Onicon F-3500 Series.

2.04 AIR-CONTROL DEVICES
A. Manual Air Vents:
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Screwdriver or thumbscrew.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 225 deg F.
B. Expansion Tanks:
   1. Expansion tanks shall be bladder type, welded steel, designed, constructed, certified and stamped in accordance with ASME BPVC-VIII-1-2013 for a working pressure of 125 psig at 240°F. Bladders shall be replaceable elastomeric butyl rubber type.
   2. Manufacturers: Bell & Gossett, Flo-Fab.
C. In-Line Air Separators:
   1. Centrifugal inline tank type, capable of handling the water flow indicated on the drawings and constructed for 125 psig working pressure.
   2. Manufacturer: Bell & Gossett, Flo-Fab.

2.05 HYDRONIC PIPING SPECIALTIES
A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
B. Stainless-Steel Bellow, Flexible Connectors:
   2. End Connections: Threaded or flanged to match equipment connected.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

C. P.T. Test Plugs:
1. Provide 1/4 inch solid brass pressure/temperature test plugs at locations shown on drawings.
2. Nordel self-closing valve to be rated for 275 degrees F. service.
3. Plugs to be manufactured by Flow Design, Peterson Engineering, SISCO, or equal.

D. Pressure/Temperature Test Kit:
1. Provide Owner complete portable pressure and temperature test kit.
2. Kit to be complete with pressure test gauge, necessary connector hoses, temperature test thermometer with adapter, shutoff and vent valves and carrying case.
3. Readout kit to be manufactured by Bell & Gossett ITT or equal.

E. Pressure Gauges:
1. Provide 4-1/2 inch dial, liquid filled pressure gauges at locations shown on drawings.
2. Gauges to be equal to Trerice Model No. 500X with glycerin liquid fill, nylon, steel, or aluminum case, acrylic plastic window, brass movement, phosphor bronze bourdon tube, and brass socket.
3. Accuracy to be guaranteed within one-half percent.
4. Select scale range of gauges to indicate design pressure near midpoint of scale.
5. Provide each gauge with 1/4 inch size, brass construction needle valve equal to Trerice Model No. 735-2.
6. Provide each gauge with impulse dampener equal to Trerice Model No. 870.

F. Thermometers:
1. Provide Trerice or equal 9-inch scale, adjustable angle (rear, front, and side), industrial thermometers at locations shown on drawings.
2. Each thermometer to have aluminum case, clear acrylic plastic window, mercury tubing, scale with white background and black markings, brass stem, and separable brass well with 2-1/2" extension neck.

G. Thermometer Wells:
1. Provide Trerice or equal stainless steel thermometer wells for water temperature sensors and at other locations shown on drawings.
2. Test wells to be stainless steel with 2-1/2 inch extension neck and screw plug cap with chain and shall be filled with light clear oil.

2.06 BYPASS CHEMICAL FEEDER - CHILLED AND HOT WATER SYSTEM
A. Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves equal to Dearborn Type AV. Feeder shall be complete with 3/2" fill opening with 1/4 turn quick opening cover that cannot be removed while feeder is pressurized.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

**PART 3 EXECUTION**

3.01 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.02 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 air separator 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 2" and larger.

D. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tank on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

F. Chemical Treatment: Install complete systems in accordance with manufacturer’s installation instructions. Provide all piping and tubing materials for interconnection of components.

END OF SECTION
PART 1  GENERAL

1.01  GENERAL

A. Pump manufacturer shall furnish and be responsible for the selection, compatibility and performance of each unit consisting of pump, motor, coupling and base plate.

B. Motor horsepower indicated on schedule is selected to allow non-overloading operation of pump. Pumps shall not be selected requiring impeller sizes within 10 percent of maximum impeller size for that pump size and/or have an efficiency of 75 percent or less.

PART 2  PRODUCTS

2.01  END-SUCTION CENTRIFUGAL PUMPS

A. Provide Bell & Gossett Series 1510 or Flo Fab Series 2000.

B. Description: Factory-assembled, non-overloading, single stage, end suction, horizontally frame-mounted, flexible coupled, bronze fitted, centrifugal type pump.

C. Pump Construction:

1. Casing: Radially split, back-pullout-design, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.


4. In "Mechanical Seal" Subparagraph below, retain "Buna-N" option for temperature rating of 225 deg F; retain "EPT" option for 250 deg F.

5. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.


7. Mount pump volute solidly to base through a pedestal support.

8. Provide motor rated for inverter duty used for systems with variable frequency drives.

D. Coupling and Base Plate

1. Manufacturer to furnish and mount pump and motor on common steel base plate with drip pan and drain connection.
2. Manufacturer to furnish and mount flexible coupling. Fasten metal coupling guard to pump base plate.
3. NAMEPLATE: Provide pump and motor with stainless steel or aluminum nameplate securely fastened to casings. Nameplates to provide all data necessary for equipment identification and replacement.

E. Motor: Single speed and rigidly mounted to pump casing with integral pump support.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Motor Requirements for HVAC Equipment."

2.02 PUMP SPECIALTY FITTINGS

A. Suction Diffusers and Triple Duty Valves to be manufactured by Bell & Gossett ITT or Flo Fab.

B. Suction Diffuser:
   1. Angle pattern.
   2. 250-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
   3. Bronze startup and bronze or stainless-steel permanent strainers.
   4. Bronze or stainless-steel straightening vanes.
   5. Drain plug.
   6. Bottom blowdown connection, inlet gauge port and adjustable support foot to carry weight of suction piping.

C. Triple-Duty Valve:
   1. Angle or straight pattern.
   2. 250-psig pressure rating, cast-iron body, pump-discharge fitting.
   3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
   4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 EXECUTION

3.01 PUMP INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Equipment Mounting:
1. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Isolation for HVAC."

3.02 ALIGNMENT

A. Perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.03 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping, Valves and Specialties."

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

C. Where installing piping adjacent to pump, allow space for service and maintenance.

D. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

E. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

F. Install triple-duty valve on discharge side of pumps.

G. Install suction diffuser and shutoff valve on suction side of pumps.

H. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

I. Provide one spare set of bearings and seals for each pump supplied.

J. Provide drip pans.

K. Install compound pressure gauges on pump suction and discharge. Reference detail on drawings.
END OF SECTION
SECTION 23 31 13

SHEET METAL DUCTWORK - LOW PRESSURE

PART 1  GENERAL

1.01  DUCTWORK

A. Low pressure ductwork refers to systems operating at 2.0" w.g. total static pressure with velocities up to 2000 FPM.

B. Provide and/or construct all materials, ductwork, joints, transitions, dampers, access doors, etc., as set forth in these specifications necessary to install the low pressure sheet metal ductwork required by the Mechanical Drawings.

C. Seal all duct openings with plastic during construction. Protect the return/negative pressure side of ductwork system throughout the entire construction period.

1.02  PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with the latest edition of SMACNA "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 shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA "HVAC Duct Construction Standards" (Metal and Flexible).

PART 2  PRODUCTS

2.01  RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA "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," "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Rectangular Duct/Longitudinal Seams," for static-pressure class,
applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 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. Manufacturer: Eastern Sheet Metal, SEMCO.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows shall be smooth radius with a centerline radius of 1.5 times the duct diameter.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "90 Degree Tees and Laterals," and "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."

2.03 Duct Access Doors

A. Provide insulated, factory fabricated access doors with dual latches and gaskets along perimeter. Door shall match leakage and pressure class ratings of duct where door is located.
2.04 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. 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.

2.05 JOINT SEALER

A. Manufacturer by Hardcast Inc., Two Stage Sealant Process.
   1. Stage 1: Apply fiber DT tape.
   2. Stage 2: Brush on RTA-50 sealant over fiber tape.

2.06 GASKETS AND SEALS

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

B. 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.

2.07 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
   2. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

**PART 3  EXECUTION**

3.01 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.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Seal all low pressure transverse and longitudinal joints with approved sealer in accordance with manufacturer's recommendation instructions.

D. Install round ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal.
thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233713 "Sheet Metal Specialties" for fire and smoke dampers.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.02 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.

3.03 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."

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-acted 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-acted concrete fasteners after concrete is placed and completely cured.
   3. Use powder-acted concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

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

3.06 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:
   1. Ducts Connected Downstream from Terminal Units:
      a. Pressure Class: Positive 2-inch wg.
   2. Ducts Connected to Single Zone-Volume Air-Handling Units:
      a. Pressure Class: Positive 2.5-inch wg.
   3. Ducts Connected Variable-Air-Volume Terminal Units:
      a. Pressure Class: Positive 2-inch wg.

C. Return/Exhaust Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 2-inch wg,
D. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 1-inch wg.

E. Outdoor-Air Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 2-inch wg.

F. Intermediate Reinforcement:

G. Elbow Configuration:
   1. Rectangular Duct: Elbows shall be smooth radius with a centerline radius of 1.5 times the duct diameter.

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

I. Side Takeoff Fittings:
   1. Minimum 26 gauge: galvanized steel, designed for minimum pressure drop by an expansion from a rectangular connection to a round duct. The fitting shall include a 1" wide mounting flange with die formed corner clips, prepunched mounting holes, and an adhesive-coated flange gasket. The outlet collar shall be crimped and incorporate a bead.
   2. Manufacturer: Crown, of Flexmaster.

END OF SECTION
SECTION 23 31 15

SHEET METAL DUCTWORK - MEDIUM PRESSURE

PART 1  GENERAL

1.01  DUCTWORK

A. Medium pressure ductwork refers to systems with velocities greater than 2000 fpm operating at a static pressure of 6" or less, but greater than 2" wg.

B. The contractor shall provide and/or construct all materials, ductwork, joints, transformations, fittings, access doors, etc., as set forth in these specifications necessary to install the medium pressure sheet metal ductwork required by the drawings.

C. Seal all duct openings with plastic during construction.

1.02  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 shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

PART 2  PRODUCTS

2.01  RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards" 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," "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards".

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards", "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other
D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 ROUND AND FLAT OVAL 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. Manufacturer: Eastern Sheet Metal, SEMCO.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards" for static class.
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows shall be smooth radius with a centerline radius of 1.5 times the duct diameter.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "90 Degree Tees and Laterals," and "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards" for static class.

2.03 INTERNALLY INSULATED DOUBLE WALL DUCT AND FITTINGS

A. Construction to be comprised of airtight outer pressure shell, 1" insulation layer, and perforated metal inner line completely covering insulation.
B. Provide outer pressure shell manufactured from galvanized steel meeting ASTM A-525. Duct and fitting construction to be as specified for single wall round and flat oval duct.

C. Provide inner liner manufactured from galvanized steel meeting ASTM A-525 in the following minimum gauges:

<table>
<thead>
<tr>
<th>Diameter or Minor Axis, Inches</th>
<th>Duct, Perforated Inner Liner</th>
<th>Fitting, Perforated Inner Liner</th>
</tr>
</thead>
<tbody>
<tr>
<td>0&quot; - 34</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>35&quot; - 59</td>
<td>26</td>
<td>22</td>
</tr>
<tr>
<td>60+</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

D. Perforations not to exceed 3/32" diameters. Percentage of open area to equal 13 percent.

E. Support inner liners of both duct and fittings with metal spacers welded in position to maintain spacing and concentricity.

F. Provide inner couplings to align inner lining to maintain airflow conditions equivalent to standard single wall medium-pressure duct joints. Butt joints are not acceptable for inner liner. Accomplish alignment by extending liner of fitting for slip joint into duct or by use of double, concentric coupling with two couplings held by spacers for rigidity and wall spacing. Provide insulation end fitting where internally insulated duct connects to uninsulated duct or fitting, fire damper, or flex to bring outer pressure shell down to nominal size.

G. Duct Access Doors
   1. Provide double wall, insulated, factory fabricated access doors with dual latches and gaskets along perimeter. Door shall match leakage and pressure class ratings of duct where door is located.

2.04 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards" for acceptable materials, material thicknesses, and duct construction methods for static class. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. 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.

2.05 JOINT SEALER

A. Manufactured by Hardcast Inc., Two Stage-Sealant Process.
   1. Apply fiber DT tape.
   2. Brush on RT A-50 sealant over fiber tape.
2.06 GASKETS AND SEALS

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

B. 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.

2.07 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electro galvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
2. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 EXECUTION

3.01 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.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards" for static pressure.

C. Seal all low pressure transverse and longitudinal joints with approved sealer in accordance with manufacturer's recommendation instructions.

D. Install round ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233713 "Air Duct Accessories" for fire and smoke dampers.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. All exposed ductwork shall be fabricated from paint grip sheet metal.

B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
D. 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.

E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 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."

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233713 "Sheet Metal Specialties."

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

3.06 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Intermediate Reinforcement:

C. Elbow Configuration:
   1. Rectangular Duct: Elbows shall be smooth radius with a centerline radius of 1.5 times the duct diameter.

D. Branch Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards," "Branch Connection for medium pressure ductwork."
      a. Rectangular Main to Rectangular Branch: 45-degree entry.
      b. Spun long radius bellmouth connections to be used at each round take off from medium pressure duct mains and plenums.
   2. Round: Comply with SMACNA's "HVAC Duct Construction Standards," "90 Degree Tees and Laterals," and "Conical Tees." Saddle taps are permitted in existing duct.

E. Side Takeoff Fittings:
   1. Minimum 26 gauge: galvanized steel, designed for minimum pressure drop by an expansion from a rectangular connection to a round duct. The fitting shall include a 1" wide mounting flange with die formed corner clips, prepunched mounting holes, and an adhesive-coated flange gasket. The outlet collar shall be crimped and incorporate a bead.
   2. Manufacturer: Crown, of Flexmaster.

3.08 LEAK TESTING

A. Install medium pressure ductwork to be pressurized to 50% over design operating pressure of 6" wg. whichever is greater. Air leakage at test pressure to be measured by a calibrated orifice type flow meter. Total
allowable leakage of system shall not exceed 1/2 of 1% of system air handling capacity.

END OF SECTION
SECTION 23 36 00
AIR TERMINAL UNITS

PART 1  GENERAL

1.01  REQUIREMENTS

A. Variable volume air terminal units to be pressure independent, single duct, DD control type with hot water reheat coil as manufactured by Johnson Controls or Titus.

PART 2  PRODUCTS

2.01  VARIABLE VOLUME AIR TERMINAL UNITS

A. Provide pressure independent, single duct, DDC control type with hot water reheat coil as manufactured by Johnson Controls or Titus. Provide units complete with pressure taps and airflow curves for making air flow and pressure measurements. Terminal units to be pressure independent. Terminal unit airflow to be monitored by an integral, multiple point, averaging airflow sensing ring or cross to maintain constant airflow within 5 percent of rated cfm down to 25 percent of nominal cfm, independent of changes in system static pressure. Factory set, field adjustable settings for terminal unit maximum and minimum airflows to be provided in accordance with schedule on drawings. Integral flow taps and calibration chart to be provided for each terminal unit.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Provide terminal units with minimum 22-gauge welded steel housing. Casing shall be internally lined with 1/2” thick fiberglass insulation.

1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
2. Air Outlet: S-slip and drive connections, size matching inlet size.
3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 6-inch wg inlet static pressure.

E. Hydronic Heating Coils: Provide factory mounted hot water reheat coils. Coils shall have a minimum .025” inch thick copper tube, with mechanically bonded aluminum fins. Design for minimum 200 psig and
220° F. Aluminum fins shall be a minimum of .0075 inch thick and spaced at a maximum of 12 fins/inch. Headers shall be heavy cast iron or steel. Designs shall be for a minimum operation of 200 psig at 220 degrees F. Coil casing shall be insulated with fiberglass duct wrap.

F. G. Maximum room N.C. due to discharge or radiated sound shall not exceed NC-35 when terminals are either in throttled or full open position with inlet static pressure ranging from 0.5 to 2" w.g. Correction of noise excesses not to constitute additional charges.

G. Controls:
1. Terminal units to be complete with factory installed, direct digital control actuator for connection to DDC controls provided by control contractor.
2. Coordinate controls with control contractor.

2.02 CASING LINER

A. Casing Liner: 1/2-inch thick elastomeric closed cell foam insulation. Insulation to be UL listed and meet NFPA-90A and UL-181 requirements.

2.03 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and AHRI certification seal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide 3 diameters of straight duct at entrance to the terminal box. Final tie-in to the box shall be properly aligned so as not to restrict airflow into the box.

3.02 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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 and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. 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.

3.03 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain 36" clear on VAV terminal unit for piping and control access.

C. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

D. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping, Valves, and Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

E. Comply with requirements in Section 233113 "Sheet Metal Ductwork - Low Pressure" for connecting ducts to air terminal units.

F. Make connections to air terminal units with flexible connectors complying with requirements in Section 233713 "Sheet Metal Specialties."

G. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

END OF SECTION
SECTION 23 37 13
SHEET METAL SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Grilles, registers and diffusers shall be provided with frames, borders, and mounting attachments for installation in the actual wall, soffit and ceiling construction in which installed.

PART 2 PRODUCTS

2.01 AIR DISTRIBUTION TERMINALS

A. CD-1: Provide Square Ceiling diffusers equal to Titus Omni or approved equal with round duct collar, square center plaque face panel with 360 degree air pattern, all aluminum construction with sliding radial damper, where indicated on the drawings. The back of the face panel shall have an aerodynamically shaped, rolled edge to ensure a tight horizontal discharge pattern. Frame to match ceiling type. Finish shall be baked on, off-white enamel.

B. SD-1: Provide linear slot ceiling & side wall diffusers equal to Titus ML-39 or approved equal at all locations designated by schedule on drawings. Diffusers to be complete with horizontal to vertical airflow pattern adjustment. Minimum lengths of continuous border sections to be as indicated. Diffuser shall be furnished in multiple sections and joined together end-to-end with alignment pins to form a continuous slot appearance. Slot width to be one-inch. Total number of slots required to be indicated on drawings. Finish to be clear anodized aluminum. Provide flanged border and concealed mounting. Internal airflow pattern adjustment mechanism to be flat black. Provide each diffuser with insulated plenum with round duct connection, Titus MPI-39.


D. RG-1: Provide aluminum construction 24x24 return register complete with opposed blade damper and 1/2" x 1/2" x 1" cube egg-crate grid. Finish shall be off-white, baked on enamel. Reference architectural ceiling plans for lay-in or surface mount frame requirements.

E. SR-2: Sidewall Return Registers (Scene Shop): Provide Ruskin ELF15J fixer louver face, 45 degree, steel with white finish for paint adhesion.
2.02 FIRE DAMPERS

A. Fire dampers to be U.L. listed Dynamic in accordance with UL-555. Fire dampers to be held in an open position with a 165 degree F fusible link and arranged to lock in position on closure.

B. Fire dampers for rectangular duct to be type "B" and for round duct to be Type "C". Fire dampers for ductwork with a static pressure rating greater than 2" wg shall be Type "C". Fire dampers located behind sidewall registers and grilles and others specifically indicated on drawings to be Type "A". Fire dampers to be multi-leaf type with spring closing for horizontal mounting and weighted-gravity closing for vertical mounting. Dampers to be steel construction with rust resistant finish and provided with a factory-installed mounting sleeve suitable for structure. Mount per manufacturer's published U.L. approved installation instructions.

C. See Architectural drawings for hour-rating of walls and/or floors. Dampers to be compatible with hour ratings.

2.03 COMBINATION FIRE AND SMOKE DAMPERS

A. Low pressure ductwork: Ruskin Model FSD-36.


C. Install and mount qualified operator at time of fabrication by damper manufacturer. Furnish damper and operator by a single entity meeting applicable UL 555S qualifications for both damper and operator. Damper operator shall be of adequate size to open or close damper in 15 seconds.

2.04 SMOKE DAMPERS

A. Low pressure duct (2" pressure class and lower): Ruskin SD-35.

B. Medium pressure duct (4" - 6" pressure class): Ruskin SD-60.

C. Operators: Electric.

D. Install and mount qualified operator at time of fabrication by damper manufacturer. Operator shall be mounted out of airstream in accessible location. Furnish damper and operator by a single entity meeting applicable UL 555S qualifications for both damper and operator. Damper operator shall be adequate size to open or close damper in 15 seconds.

2.05 SLEEVES

A. Unless otherwise required by the authority having jurisdiction, sleeves for fire dampers and fire and smoke combination dampers shall be the rigid type of construction recommended in Schedule 2 of SMACNA Publication for "Fire Damper and Heat Stop Guide for Air Handling Systems". Use 16...
gauge for ducts 24" or less in diameter or either rectangular dimension and 14 for ducts over 24". Provide minimum 18" long sleeves. Coordinate required length with wall thicknesses.

B. Conform to the requirements of UL 555S. Test damper and operator as a unit to comply with UL 555S.

C. Install 1-1/2" x 1-1/2" x 1/8" angle bar on four sides of sleeves and both sides of wall.

D. Fasten angles to sleeve only.

E. Do not fasten angles to the wall.

2.06 AUTOMATIC CONTROL DAMPERS

A. All automatic control dampers to be furnished by Control subcontractor and installed by this Contractor (except unit mounted dampers).
   1. Automatic control dampers to be low-leak, galvanized steel or aluminum construction parallel blade type, Ruskin Model CD36, Arrow Series 395, or approved equal.
   2. Dampers to be complete with minimum 4" deep, 16-guage hat-shaped channel frame, minimum 16 gauge blades on maximum 6" centers, 1/2" diameter shafts, and corrosion resistant bearings.
   3. Dampers to have extruded vinyl blade seals and stainless steel or aluminum flexible metal compression type jamb seals to limit leakage to a maximum of ½% (maximum of 5.4 cfm/sq. ft. leakage for 48" x 48" size damper) when tested in accordance with AMCA Standard 500.
   4. Motor actuator to be oil immersed in gear train, 120- volt line voltage type with spring return to closed position on power interruption. Provide Honeywell Model M445/845, Barber-Colman MA-5210/5330 or approved equal complete with damper linkages.

2.07 MANUAL VOLUME DAMPERS

A. Type: Opposed blade.

B. Material: Steel, 3V type blades mounted in steel channel frame.

C. Shaft: 1/2" square rod operator with end bearings and gasket seal at duct penetrations. Terminate shaft in damper frame with bushings.

D. Operator: Locking quadrant handle with damper position indicator and insulation stand off mounting bracket for externally insulated ductwork.

2.08 FLEXIBLE CONNECTORS

A. Install UL listed flexible duct connectors between duct and fan/equipment connections. Flexible duct connectors to be made of 28-ounce, heavy glass fabric double coated with neoprene.
2.09 DUCT ACCESS DOORS

A. Duct access doors to be provided for access to all coils, fire dampers, automatic and backdraft dampers, duct smoke detectors, static pressure and air volume sensing devices, and other equipment installed in ducts and at other points indicated on drawings.

B. Access door construction and air tightness must be suitable for the duct pressure class used (low, medium, or high).

C. Access doors to be double-panel, galvanized steel construction with minimum 1" rigid insulation between panels. Access doors in exhaust duct may be uninsulated single panel, galvanized steel construction. Doors to mount in rigid frame constructed of formed galvanized steel. Angle iron bracing to be used as required to provide rigid assembly. Doors to hinge on one side with door latch on opposite side.

D. Access doors in ductwork shall fully comply with Figure 2-12 and 2-13 of SMACNA manual. Casing access doors shall fully comply with Figure 6-11 and 6-12 of SMACNA manual.

E. Doors to close against gasket seal.

F. Ductwork and/or equipment access doors shall be required at all motorized dampers, fire dampers, smoke detectors, airflow monitoring stations, duct-mounted temperature/pressure sensors and/or transmitters, vaned elbows, and any other mechanical and/or control device requiring inspection, maintenance or test access. In addition, 24" x 24" access doors shall be utilized wherever possible to facilitate adequate access for maintenance and/or testing.

2.10 FLEXIBLE DUCT (NON-CRITICAL NOISE AREAS ONLY)

A. Acceptable manufacturers:
   1. Flexmaster U.S.A., Model No. Type 5 insulated; Wiremold; Omniair 1200; J.P. Lanburn.

B. Characteristics of flexible duct to air terminals:
   1. Approved as UL Class 1 air duct.
   2. Flame spread less than 25, smoke developed rating less than 50.
   3. Insulated with 1/2" thick fiberglass insulation.
   4. Do not exceed four (4) feet flexible duct upstream of diffusers.
   5. Flexible duct shall meet standards of local building code.

C. Seal off the insulation jacket as its ends and at joints with mastic, hardcast, or similar material. Replace flex if jacket is punctured.

D. Install flexible duct without kinks or sags and support with 3/4" wide metal bands.
E. Do not route flexible duct through corridor walls, fire or smoke partitions.

F. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per four foot length of duct material.

2.11 BACKDRAFT DAMPERS

A. Backdraft Dampers (BDD): Backdraft dampers to be Ruskin Model CBD6 or approved equal low-leak counterbalanced backdraft dampers. Dampers to be heavy-duty type suitable for air velocities to 2500 fpm with all extruded aluminum construction, minimum 0.81” thick frame, and minimum .050” thick blades on maximum 4” centers. Provide blades with vinyl edge seals. Provide dampers with aluminum linkage and corrosion resistant type bearings. Provide dampers with adjustable counterbalances on blades to assist closing.

2.12 ROOF HOODS

A. Fabricate air inlet or relief hoods in accordance with SMACNA Low Pressure Duct Construction Standards.

B. Fabricate of 0.081 gauge extruded aluminum tiers welded to a minimum 8 gauge aluminum support structure. The aluminum hood shall be constructed of minimum 0.063 aluminum and provided with a layer of anti-condensate coating. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. Birdscreen constructed of 1/2” galvanized mesh shall be mounted across the relief openin.

C. Mount unit on minimum 14 inch high curb base with insulation between duct and curb.

D. Provide counterbalanced, adjustable barometric dampers in all relief hoods.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install sheet metal accessories in locations shown on drawings.

B. Install accessories in accordance with manufacturer’s published recommendations as well as applicable sections of SMACNA manual and other standards set forth in Part 1.

C. Provide all screw, bolts, nuts, inserts, and material required for attaching sheet metal to duct, walls, floors, and ceilings.

D. Install spin-in fitting with balancing damper in duct runout.
E. Provide minimum 24" x 24" access door in inaccessible ceilings and walls where needed for access to any inaccessible duct access doors or other mechanical equipment including valves, dampers, VAV boxes, etc.

3.02 TESTING

A. Check work for satisfactory installation and performance.

B. Insure that adequate access does in face exit for fire and smoke dampers and that damper operator motors are not hindered in operation by proximity to walls or other objects.

C. Check duct connections at access doors for air leakage or condensation. Correct conditions found.

END OF SECTION
SECTION 23 41 00

AIR FILTERS

PART 1  GENERAL (NOT APPLICABLE)

PART 2  PRODUCTS

2.01  PERFORMANCE REQUIREMENTS

A.  ASHRAE Compliance:
1.  Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2.  Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
3.  All filters to meet NFPA 90A requirements for flammability.

B.  Comply with NFPA 90A and NFPA 90B.

2.02  MERV-8 DISPOSABLE FILTERS

A.  Provide 30% medium efficiency, disposable, pleated media filters equal to Farr 30/30/ with a minimum rating of MERV-8 per ASHRAE 52.2 - 1999.

B.  Each filter shall consist of a non-woven cotton media, media support grid, and enclosing frame.

C.  Filter shall be listed by UL as Class II.

D.  Average efficiency of MERV-8 on ASHRAE Test Standard 52.2-1999.

E.  2-Inch Thick Media: Effective filter media area shall not be less than 4.6 square feet of media per square foot of face area.

F.  Provide one complete set of replacement filters to Owner at job completion.

2.03  FILTER GAGES

A.  Manometer-Type equal to Dwyer inclined tube draft gage.

PART 3  EXECUTION

3.01  INSTALLATION

A.  Install filter gage for each filter bank for each air handling unit.

B.  Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
C. Install filtergage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

D. Coordinate filter installations with duct and air-handling-unit installations.

E. Contractor shall provide a new set of clean filters during construction bi-weekly if unit is operating.

F. Protect cooling coils and heating coils with filter media during construction.

G. Install temporary filters over grilles and openings on weekly basis during construction.

END OF SECTION
SECTION 23 51 23

GAS VENTS

PART 1   GENERAL

1.01    SUMMARY

A.    Section Includes: Listed double-wall vents.

PART 2   PRODUCTS

2.01    DOUBLE WALL POSITIVE PRESSURE SYSTEM

A.    Provide UL tested and listed double wall pipe and fittings suitable for forced/induced draft boilers.

B.    Suitable for use with natural gas.

C.    Maximum 1000 degrees F continuous operating temperature, or 1400 degrees F intermittent.

D.    Inner Shell:
   1.  20 gauge 304 stainless steel for natural gas.

E.    Outer shell: 24 gauge aluminum coated steel.

F.    Shell Separation: 1 inch air space.

G.    Minimum rated clearance to combustibles: 10 inches.

H.    Couplings: Flanged containment band.

I.    AMPCO Model VSI-2, Metalbestos Model PS, or approved equal.

PART 3   EXECUTION

3.01    APPLICATION

A.    Install double wall vent per manufacturer's installation instructions.

3.02    INSTALLATION OF LISTED VENTS

A.    Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B.    Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
C. Support vents at intervals recommended by manufacturer to support weight of vent and all accessories.

D. Lap joints in direction of flow.

E. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION
PART 1  GENERAL

1.01  PACKAGED AIR-COOLED WATER CHILLERS

A. Acceptable Manufacturers: York YLAA and Carrier 30RB Scroll Type Chillers.

B. Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

C. Cabinet:
   1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
   2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
   4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
   5. Sound-reduction package consisting of the following:
      a. Acoustic enclosure around compressors.
      b. Reduced-speed fans with acoustic treatment.
      c. Designed to reduce sound level without affecting performance.
   6. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

D. Compressors:
   1. Description: Positive-displacement direct drive with hermetically sealed casing.
   2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
   5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

E. Compressor Motors:
1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

F. Compressor Motor Controllers:
1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

G. Refrigeration:
1. Refrigerant: R-410a. Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

H. Evaporator:
1. Brazed-plate or shell-and-tube design, as indicated.
2. Shell and Tube:
   a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
   b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   c. Shell Material: Carbon steel.
   d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
   e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
   f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
3. Brazed Plate:
   a. Direct-expansion, single-pass, brazed-plate design.
   b. Type 316 stainless-steel construction.
   c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
4. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.
5. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
I. Air-Cooled Condenser:
1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig.
   a. Construct coils of copper tubes mechanically expanded to aluminum fins.
   b. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
3. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
4. Fan Guards: Steel safety guards with corrosion-resistant coating.

J. Electrical Power:
1. Factory-installed and wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
2. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
3. Wiring shall be numbered and color-coded to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch.
6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. NEMA KS 1, heavy-duty, nonfusible switch.
   c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
10. Provide power factor correction capacitors to correct power factor to 0.95 at full load.
11. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
   a. Power unit-mounted controls.
   b. Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
13. Indicate the following for water chiller electrical power supply:
   a. Current, phase to phase, for all three phases.
b. Voltage, phase to phase and phase to neutral for all three phases.
c. Three-phase real power (kilowatts).
d. Three-phase reactive power (kilovolt amperes reactive).
e. Power factor.
f. Running log of total power versus time (kilowatt hours).
g. Fault log, with time and date of each.

K. Controls:
1. Stand-alone, microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
   a. Date and time.
   b. Operating or alarm status.
   c. Operating hours.
   d. Outside-air temperature if required for chilled-water reset.
   e. Temperature and pressure of operating set points.
   f. Entering and leaving temperatures of chilled water.
   g. Refrigerant pressures in evaporator and condenser.
   h. Saturation temperature in evaporator and condenser.
   i. No cooling load condition.
   j. Elapsed time meter (compressor run status).
   k. Pump status.
   l. Antirecycling timer status.
   m. Percent of maximum motor amperage.
   n. Current-limit set point.
   o. Number of compressor starts.

4. Control Functions:
   a. Manual or automatic startup and shutdown time schedule.
   b. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water temperature.
   c. Current limit and demand limit.
   d. External water chiller emergency stop.
   e. Antirecycling timer.
   f. Automatic lead-lag switching.

5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
   a. Low evaporator pressure or high condenser pressure.
   b. Low chilled-water temperature.
   c. Refrigerant high pressure.
   d. High or low oil pressure.
   e. High oil temperature.
   f. Loss of chilled-water flow.
   g. Control device failure.

6. BAS Communications: BAC net MS/TP

L. Insulation:
1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
2. Thickness: 1-1/2 inches.
3. Factory-applied insulation over cold surfaces of water chiller components.
   a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Apply protective coating to exposed surfaces of insulation.

M. Accessories:
   1. Factory-furnished, chilled-water flow switches for field installation.
   2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
   3. Factory-furnished neoprene or spring isolators for field installation.

N. Perform functional test of water chillers before shipping.

O. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

P. Rate sound power level according to ARI 370 procedure.

PART 2 PRODUCTS

2.01 WATER CHILLER INSTALLATION

A. Install water chillers on support structure indicated.

B. Equipment Mounting:
   1. Install water chillers on grade on a 6" thick concrete pad.
   2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Isolation for HVAC."

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

E. Provide 5 year compressor warranty. Manufacturer shall warrant all equipment and material of its manufacture against defects in workmanship and material for a period of eighteen (18) months from date of shipment or twelve (12) months from date of start up, whichever occurs first.

F. Install separate devices furnished by manufacturer and not factory installed.
2.02 CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping, Valves, and Specialties. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve. Make connections to water chiller with a union, flange, or mechanical coupling.

D. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

2.03 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
   2. Verify that pumps are installed and functional.
   3. Verify that thermometers and gages are installed.
   4. Operate water chiller for run-in period.
   5. Check bearing lubrication and oil levels.
   7. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

END OF SECTION
SECTION 23 74 13

MODULAR, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1  GENERAL

1.01 PERFORMANCE

A. Certify unit components in accordance with ARI Standard 430 as applicable.

B. Certify coils in accordance with ARI Standard 410.

PART 2  PRODUCTS

2.01 MANUFACTURERS

A. JCI, Trane, Daiken.

2.02 CASING CONSTRUCTION

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.

3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.

4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, exhaust fans, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.

7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.

9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

10. Unit shall include lifting lugs on the top of the unit.

2.03 FANS

A. Provide supply fan section with plenum fan designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Fan wheel shall be properly secured to shaft to prevent slippage.

B. Provide internal factory mounted canvas duct connection at fan discharge connection to fan module.

C. Provide self-aligning, grease lubricated pillow-block ball bearings with lubrication fittings. Provide extended grease lines to drive side of unit casing, for all fan bearings, rigidly attached for easy service access. Units shall include access doors on both sides of the units. All bearings shall perform to L-50 200,000 hour average life.

D. Fan, motor and drive shall be factory mounted with manufacturer's standard vibration isolation devices having a minimum of 2 inches static deflection.

2.04 COOLING COILS

A. Chilled Water Cooling Coil:
   1. Coils to be constructed of 5/8" outside diameter tubing (0.024 inch thick) with not more than 11 fins per inch with minimum .009" thick aluminum fins and cast iron or copper headers. Bond fins by mechanical expansion.
   2. Provide coils with a maximum working pressure of 175 psig at 200 degrees F.
3. Provide circuited drainable coils with vent connection at highest point and drain connection at lower point.

2.05 HOT WATER PRE-HEAT AND RE-HEATING COILS:

A. Coil to be constructed of 5/8” outside diameter tubing (0.024 inch thick) with minimum .009” thick aluminum fins and cast iron or copper headers. Bond fins by mechanical expansion.

B. Provide coils with a maximum working pressure of 175 psig at 200 degrees F.

C. Provide circuited drainable coils with vent connection at highest point and drain connection at lower point.

2.06 FILTERS

A. Unit shall include 2 inch thick, pleated panel filters with an ASHRAE efficiency of 35% and a MERV rating of 8, upstream of the cooling coil.

B. Unit shall include a clogged filter switch.

2.07 OUTSIDE AIR/ECONOMIZER

A. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq. ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return enthalpy activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood, and barometric relief dampers.

2.08 ADDITIONAL SECTIONS

A. Double Wall Filter Section:

1. Provide factory-built filter section complete with filters as specified herein. Minimum filter area to be as specified on unit schedule but not to exceed 500 fpm filter face velocity. Filter sections to have full sized, hinged, latched, double wall access doors on both sides of section for filter service.

2. Provide medium efficiency (MERV 8), 2” thick pleated disposable type panel filters equal to Farr 30/30.

3. Provide a factory mounted Dwyer inclined tube draft gage across each filter section and mark gage to indicate design clean and dirty loading conditions.

4. Provide one complete set of replacement filters to Owner at job completion.
B. Double wall mixing section to have low-leak type outside and return air dampers with parallel blades. Arrange dampers so outside and return air merge when entering mixing box. Damper rods to rotate in nylon bushings.

C. Provide coil access section for placement at chilled water coil, hot water coil, filter mixing section, energy recovery wheel, and fan. Access doors shall be located on both sides of sections. Doors shall be full sized, hinged, latched, and double wall.

D. Provide unit manufactured, insulated piping vestibules for chilled water coil, pre-heat hot water coil and re-heat hot water coils.

2.09 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with motorized damper filter.

B. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
   1. Damper Motor: Modulating with adjustable minimum position.
   2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

2.10 AHU CURBS

A. Curbs shall be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the unit and mounted on the curb immediately before mounting of the unit.

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   1. Curb Insulation and Adhesive: Comply with NFPA 90A.
      a. Materials: ASTM C 1071, Type I or II.
      b. Thickness: 2 inches.
   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
      b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C 916, Type I.

**PART 3  EXECUTION**

**3.01 INSTALLATION**

A. Equipment Mounting:
   1. Install outdoor air handling units on factory roof curb.

B. Curb: Install in accordance with manufacturer's instructions.

C. Unit Support: Install unit level on curb. Secure AHU's to equipment rails with anchor bolts.

D. Install condensate drain, minimum connection size, with trap and indirect connection to nearest area drain.

E. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Connect supply ducts to AHU's with flexible duct connectors specified in Section 233713 "Sheet Metal Specialties."
   2. Install return and supply isolation plenums.

**3.02 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. Report results in writing.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:
   1. Reference Section 230593 "Testing, Adjusting, and Balancing for HVAC".

**3.03 CLEANING AND ADJUSTING**

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
B. After completing system installation and testing, adjusting, and balancing AHU's and air-distribution systems, clean filter housings and install new filters.

END OF SECTION
SECTION 23 82 19

FAN COIL UNITS

PART GENERAL

1.01 SUMMARY

A. Section includes horizontal concealed fan coil units.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

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

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.02 HORIZONTAL FAN COIL UNITS

A. Provide JCI, Trane, Daiken or approved equal.

B. Fabricated of heavy gauge panels insulated with antimicrobial elastomeric closed cell foam insulation.

C. All concealed units shall have a minimum 1-1/4 inch duct collar on the supply discharge. Provide return air plenum section with a 1-inch duct collar. Unit shall have a hinged bottom access panel.

D. All exposed units shall have a power coated finish. All exterior panels shall be finished on both sides with an anodic acrylic power paint of the standard factory color. Provide side and bottom access panels with quick open fasteners. Provide double deflection discharge grille and a bottom return grille.

E. Unit fan shall be dynamically balanced, forward curved, DWDI centrifugal type constructed of galvanized steel. Motors shall be high efficiency, permanently lubricated sleeve bearing, permanent split-capacitor type with UL listed automatic reset thermal overload protection.

F. Provide primary drain pan constructed of heavy gauge type 304 stainless steel. Stainless steel drain pans shall be externally insulated. Provide a condensate overflow switch in the primary drain pan.

G. Chilled and hot water coils shall have minimum 1/2-inch copper tubes, collared and corrugated aluminum fins. Minimum working pressure of 200 psig. Include manual air vent and drain valve.
H. Provide 1-inch pleated throwaway filter.
I. Provide piping package including 2-way modulating control valve, isolation ball valves, unions and pressure-temperature ports.
J. Thermostat shall be unit mounted with integral three speed fan switch.
K. Provide horizontal units with hanger suspension.
L. Units to have internal electrical junction box suitable for single point permanent wiring connection. Provide disconnect switch at junction box.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Install fan coil units level and plumb.
B. Install fan coil units to comply with NFPA 90A.
C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Isolation for HVAC."
D. Verify locations of thermostats and sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.
E. Install new filters in each fan coil unit within two weeks after Substantial Completion.
F. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
   3. Install condensate trap of adequate depth to seal against fan pressure.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
B. Remove and replace malfunctioning units and retest as specified above.
C. Prepare test and inspection reports.
3.03 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION
SECTION 26 05 00
ELECTRICAL GENERAL PROVISIONS

PART 1    GENERAL

1.01   WORK INCLUDED

A. Provide all materials, labor, and equipment required to furnish and install a complete electrical system as indicated on the Drawings and as specified herein.

B. Electrical work includes, but is not limited to, the following:

1. Complete distribution system for lighting and power including the necessary feeders, panelboards, branch circuits, conduit, lighting fixtures, control switches, and receptacles.
2. Excavation, trenching, and backfilling for conduit and/or cable.
3. Grounding
4. Data and Telephone system raceways, boxes, and cabling.
5. Power wiring for equipment furnished under Division 21, 22 and 23.
6. Fire Alarm System

1.02   RELATED WORK

A. The following work shall be furnished under other Divisions of these Specifications, but shall be coordinated with said Divisions by Division 26 tradesman prior to bid.

1. Flashing of conduits into roofing and outside walls.
2. Painting.
3. Cutting and patching.
4. Heating, ventilating, air conditioning, and plumbing equipment.

1.03   DEFINITIONS

A. Provide: Shall mean "furnish, install, connect, and put in good working order."
B. Wiring: Shall mean "wire and cable, installed in raceway with all required boxes, fittings, connectors, etc. completely installed."
C. Engineer: Shall mean "Engineer of Record" whose seal is affixed to the contract specifications and drawings of Division 26.

1.04   CODES AND STANDARDS

A. Comply with applicable local, state, and federal codes.
B. Electrical work shall be installed in accordance with the Drawings and Specifications, the 2011 NEC, 2012 IBC and applicable accessibility code.
C. In event of conflict between Drawings, Specifications and such codes, Engineer shall be notified in writing prior to bid. A ruling will then be made by the Engineer in writing. All work shall be installed in strict accordance with applicable codes without additional cost to Owner.

D. Contractor shall submit and/or file all necessary specifications and drawings as required by governing authorities.

1.05 SUBMITTALS

A. Provide submittals on materials and equipment identified in the Specifications and Drawings prior to manufacturer, order, or installation in accordance with Shop Drawings, Product Data, and Samples.

B. Submittals shall include but not be limited to the following:
   - Lighting fixtures
   - Switchgear
   - Fire Alarm System
   - Voice/Data/Coax Cabling
   - Cable Tray

PART 2 PRODUCTS (Not used)

PART 3 EXECUTION

3.01 SITE VISIT

A. Visit job site prior to bid date to determine actual conditions under which work shall be done, to become familiar with project, and to verify total scope of work required. Failure to do so shall not constitute a reason for an extra charge.

3.02 COMMISSIONING

A. Complete testing of all lighting, wiring, generators, etc. per TBR specifications and complete the associated standard TBR/owner checklists.

END OF SECTION
SECTION 26 05 01

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1  GENERAL

1.01 QUALITY ASSURANCE

A. Qualifications of Manufacturer: All materials and equipment used in work of Division 26 shall be produced by manufacturers regularly engaged in manufacturer of similar items and with history of successful production acceptable to the Engineer. They shall be new and be UL listed and labeled or listed and labeled by other recognized testing laboratory where such label is available.

B. Qualifications of Installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in necessary crafts and who are completely familiar with specified requirements and methods needed for proper performance of work of this Section.

1.02 GUARANTEE-WARRANTY

A. Guarantee work to be free of material and workmanship defects for a period of one year, from date of final acceptance for the project. Repair and replace defective work and other work damaged thereby which becomes defective during term of Guarantee-Warranty. Furnish Owner with three written copies of Guarantee-Warranty.

PART 2  PRODUCTS

2.01 SUBSTITUTIONS

A. Reference in Specifications to any article, device, product, material, fixture, form, and type of construction, by name, make, or catalog number shall be interpreted as established standard of quality and shall not be construed as limiting competition. Any article, device, product, material, fixture, form and type of construction which in the judgment of Engineer, expressed in writing, is equal to that specified, may be used.

B. Substitution shall be approved by Engineer before purchase and/or installation. If unapproved materials are installed, work required to remove and replace unapproved items shall be done at the Contractor’s expense.

PART 3  EXECUTION

3.01 INSTALLATION

A. Electrical drawings are diagrammatic and shall not be scaled for exact sizes or locations. They are not intended to disclose absolute or unconditional knowledge of actual field conditions.
B. Equipment shall be installed according to manufacturer's recommendations.

C. Protect work and materials from damage by weather, entrance of water, and dirt. Cap conduit during installation. Avoid damage to materials and equipment in place.

D. Satisfactorily repair or remove and replace damaged work with new materials.

E. Trenching and backfilling shall comply with Site Work of these Specifications and provide sheathing, shoring, dewatering and cleaning necessary to keep trenches and their grades in proper condition for work to be carried on. Trenches shall be excavated 6" below elevation of bottom of conduit. Backfill shall be per Site Grading and Filling.

F. Failure to route conduit through building without interfering with other equipment and construction shall not constitute a reason for an extra charge. Equipment, conduit and fixtures shall fit into available space in building and shall not be introduced into building at such times and manner as to cause damage to structure. Equipment requiring services shall be readily accessible.

G. Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
   1. Coordinate electrical systems, equipment, and materials installation with other building components.
   2. Verify all dimensions by field measurements.
   3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
   4. Coordinate the installation of required supporting devices and sleeves to be set in poured in-place concrete and other structural components, as they are constructed.
   5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
   7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
   8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work
are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, whether exposed or concealed.

10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install access panels or doors where units are concealed behind finished surfaces.

12. Insulate dissimilar metals so they are not installed in direct contact.

H. Conduits which pass through floor slabs (except ground floor) shall be sealed with Fire Stop Sealant. Seal around conduits or other wiring materials passing through partitions, floors, and fire rated walls. Use UL approved Fire Stop Sealant as detailed on the drawings.

I. Coordinate electrical power connection requirements with all equipment suppliers. Where power requirements differ from drawing design requirements, Engineer shall be notified for clarification and installation requirements prior to installing that portion of work. Cost for equipment and labor for improperly installed electrical connections not coordinated and approved by other trades and the Engineer shall be incurred by the Electrical Contractor and shall not constitute a reason for an extra charge because of rework.

3.02 CUTTING AND PATCHING

A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

3.03 TESTING AND EQUIPMENT SERVICING

A. Entire installation shall be free from improper grounds and short or open circuits. Conductors shall be tested before energizing circuit. Test to insure that entire system is in proper operating condition, and that adjustments and settings of circuit breakers, fuses, control equipment, and apparatus have been made. Correct defects discovered during tests.

3.04 REMOVAL OF DEBRIS

A. Remove surplus materials and debris caused by, or incidental to electrical work. Remove such debris at frequent intervals. Keep job site clean during construction.

3.05 IDENTIFICATION OF EQUIPMENT

A. Equipment shall be identified in accordance with Section 26.05.53,
“Electrical Identification.”

3.06 AS-BUILT DRAWINGS

A. Maintain one set of blue line electrical prints on site, marked to show as-built conditions and installations, prints to be turned over to Owner after job is complete.

3.07 TEMPORARY LIGHTING AND POWER

A. Provide, maintain and remove after construction is completed, temporary lighting adequate for workman safety and temporary power for all trades including any 1 phase power required.

3.8 POWER OUTAGES

A. Coordinate all power outages with Owner and submit for approval proposed schedule of work indicating extent, number, and length of outages required to perform work. Contractor shall include in bid cost of overtime labor required for power outage to occur after Owner’s normal hours of operation.

3.09 OTHER MATERIALS

A. Work of this Division shall also include those items not specifically mentioned or described, but which are obviously necessary to conform to the design intent, applicable codes and to produce complete electrical system that functions properly. These materials shall be as selected by Contractor but subject to approval of the Engineer.

3.10 OTHER COORDINATION

A. Contractor shall obtain and pay for all necessary permits and inspection fees required for the electrical installation.

B. Contractor shall coordinate electrical service requirements with the local electric utility company, and provide any required fee, conduit, transformer pad, metering equipment, etc. that is required.

END OF SECTION
SECTION 26 05 16

CONDUIT

PART 1  GENERAL

1.01  WORK INCLUDED

A.  Provide a complete conduit system to support all electrical equipment and systems. Conduit system includes conduit, couplers, connectors, fittings, boxes, covers and supports.

B.  No conduit serving branch circuits shall be installed in or below concrete slabs unless required for branch circuits serving loads located in the center of a room.

1.02  QUALITY ASSURANCE

A.  Listing and Labeling: Provide conduit that is listed and labeled.
1.  The term "listed and labeled": As defined in the National Electrical Code, Article 100.
2.  Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B.  Conduit and its installation shall comply with requirements of the National Electrical Code.

PART 2  PRODUCTS

2.01  CONDUIT

A.  Electric Metallic Tubing (EMT): Allied, Wheatland, LTV Copperweld, or approved equal.

B.  Rigid Metal Conduit (RMC): Allied, Wheatland, Republic, or approved equal.

C.  Flexible Steel Conduit (Greenfield): Aflex, Electroflex, Greenfield, or approved equal.

D.  Rigid Non-Metallic Conduit (PVC): Carlon Schedule 40, Cantex, Southern Pipe, Schedule 80 or approved equal.

E.  Liquid-tight Flexible Metallic Conduit (LFMC): Aflex, Electroflex, Seal-lite, or approved equal.

2.02  CONDUIT FITTINGS

B. Bushings: Appleton, T&B, O.Z., or Gedney
C. Straps and Hangers: Appleton, T&B, Steel City, or Minerallac.
D. Group Pipe supports: Unistrut, Kindorf, B-Line, or approved equal.
E. Expansion Fittings: O.Z. Gedney Type AX, or equal by Appleton, or approved equal.

PART 3 EXECUTION

3.01 CONDUIT

A. In general, conduit installation shall follow layout shown on drawings. However, this layout is diagrammatic only and where changes are necessary due to structural conditions, other apparatus or other causes, such changes shall be made without cost to Owner. Offsets in conduits are not indicated and must be furnished as required.

B. Conduit shall be installed in accordance with the National Electrical Code.

C. Provide bushings on the open ends of conduit containing conductors. Insulated bushings shall be provided for conduits containing conductors #4 AWG or larger with an insulating ring an integral part of the bushing.

D. Use EMT where Drawings call for conduit to be concealed in walls or above ceilings or when cast in concrete slabs not on grade. Do not use EMT exposed lower than 4' above floor, in wet locations, or in exterior applications.

E. Use Schedule 40 PVC encased in concrete or when installed underground. Use Schedule 80 PVC when exposed.

F. When PVC conduit is used, turn up perpendicular to slab.

G. Support conduit and secure to forms when cast in concrete so that conduit will not be displaced during pouring of concrete. Stuff boxes and cork fittings to prevent entrance of water during concrete pouring and at other times during construction, prior to completion of conduit installation.

H. Route all conduit at right angles or parallel to walls of building.

I. Use proper sized tools for bending. Do not heat metal conduit. Dents and flat spots will be rejected. Cut and thread conduit so ends will butt in couplings. Make threads no longer than necessary and ream pipe free of burrs.

J. Minimum conduit size 3/4" unless otherwise required.
K. Leave one #10 AWG or equivalent nylon pull wire in empty conduits.

L. Use short pieces, approximately five (5') feet of flexible conduit to connect motors and other devices subject to motion and vibration. Use liquid tight flexible conduit where outside or subject to water spray.

M. All elbows for communications and AV cabling shall be long-radius type, standard long radius for 1.5” and below, and 36” radius for 2” and larger conduit.

3.02 CONDUIT FITTINGS

A. When EMT is installed concealed in walls or above ceilings use steel double set screw connectors. All connectors shall have throated insulating bushing.

B. Support conduit vertically and horizontally by straps or hangers. Do not exceed intervals as described in the National Electrical Code.

C. Use expansion fittings, properly bonded to assure ground continuity, across expansion joints in floors and ceilings. Use double lock nuts and bushings on panel feeders at panel cans.

D. When connections are made to motors or other equipment, not near walls or columns, provide a vertical conduit, minimum 3/4”, attached to floor with a floor flange, bring wiring out of this conduit by means of a condulet and flexible conduit extending to equipment junction box.

END OF SECTION
SECTION 26 05 19

WIRE AND CABLE

PART 1  GENERAL

1.01 WORK INCLUDED

A. Wire and cable for all service, feeders, branch circuits, and instrument and control wiring rated 600 volts and below.

1.02 QUALITY ASSURANCE

A. Listing and Labeling: Provide wire and cable that is listed and labeled.
   1. The term "listed and labeled": As defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Wire and cable and its installation shall comply with requirements of the National Electrical Code.

PART 2  PRODUCTS

2.01 MATERIALS

A. Wires and cables shall meet applicable requirements of the National Electrical Code and UL for the type of insulation, jacket, and conductor specified or indicated.

B. All conductors shall be copper with 600 volt insulation unless otherwise indicated.

C. Wire and cable shall be manufactured by Belden, General Cable, Essex, Encore, Rome Cable, Southwire, or approved equal.

D. Use solid copper type THHN/THWN for branch circuit wiring #10 AWG and smaller. No conductor for branch circuit wiring shall be smaller than #12 AWG.

E. Use stranded copper, type THHN/THWN for feeder and power circuits #8 AWG and larger.

F. Provide color coded wire and with a different color for each phase and neutral and ground as follows: 208/120 volt circuits - phases A, B, and C: black, red, and blue respectively; neutral: white; ground: green. 480/277 volt circuits – phases A, B, and C: brown, orange, and yellow, respectively, neutral: gray; ground: green. Approved color tape is acceptable for feeders. Also provide color coded wire for control circuits.
PART 3  EXECUTION

3.01  INSTALLATION

A. Complete conduit system before pulling any wire or cable. Use cable lubricants recommended by cable manufacturer as necessary.

B. Conductors shall be continuous from outlet to outlet or to branch circuit over-current devices. Make splices only in junction boxes. Splices shall not be made in panelboards. Control wiring shall be continuous between components and/or terminal boards.

C. A minimum of eight (8”) inches of slack conductor shall be left in every outlet or junction box. There should also be enough slack so three (3”) inches extends outside the outlet or junction box.

D. Make splices in conductors #10 AWG and smaller diameter with insulated, pressure-type connector. Use Scotchlok, Ideal, or equal wire connectors.

E. Make splices in conductors #8 AWG and larger diameter with solderless connectors and cover with insulation material equivalent to conductor insulation. Use Burndy compression connectors with “crimp-it” cover, type CC, or equal.

3.02  TESTING

A. After completion of the installation and splicing and prior to energizing the conductors, wire and cable shall be given continuity and insulation tests as herein specified.

B. Test wiring to verify that no short circuits, open circuits, or accidental grounds exist. Continuity tests shall be conducted using a dc device with bell or buzzer.

C. Perform Megger tests on wiring #4 AWG and larger.

END OF SECTION
SECTION 26 05 26
GROUNDING AND BONDING

PART 1  GENERAL

1.01 WORK INCLUDED

A. Grounding electrodes and conductors.
B. Equipment grounding conductors.
C. Bonding.

1.02 PERFORMANCE REQUIREMENTS

A. The grounding system to earth resistance shall be less than 15 ohms.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide grounding and bonding materials that are listed and labeled.
   1. The term "listed and labeled": As defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Components and installation shall comply with the requirements of the National Electrical Code (NEC).

C. Materials shall comply with UL 467, “Grounding and Bonding Equipment.”

PART 2  PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers shall be Burndy, T&B, or approved equal.

2.02 GROUNDING ELECTRODES

A. Ground rods shall be copper clad steel with minimum dimensions of ¾ inch diameter by 10 feet long.

2.03 CONNECTORS

A. Exothermic welded connections shall be provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.
B. Pressure connectors shall be high-conductivity-plated units.
C. Bolted clamps shall be heavy-duty units listed for the application.

2.04 WIRE AND CABLE

A. All grounding conductors shall be copper.
B. The grounding electrode conductor shall be stranded.
C. Equipment grounding conductors shall have green insulation.
D. Bare copper conductors shall conform to the following:
   1. Solid conductors: ASTM B-3
   2. Assembly of stranded conductors: ASTM B-8
   3. Tinned Conductors: ASTM B-33

2.05 MISCELLANEOUS CONDUCTORS

A. Ground bus shall be bare annealed copper bars.
B. Braided bonding jumpers shall be copper tape, braided number 30 gauge bare copper wire, and terminated with copper ferrules.
C. Bonding strap conductor/connectors shall be soft copper, 0.05 inch thick and two (2") inches wide, unless otherwise noted.

PART 3 EXECUTION

3.01 INSTALLATION

A. Grounding system shall be in accordance with Article 250 of the NEC except where the Drawings or Specifications exceed NEC requirements.
B. Install code size green grounding conductors in all feeder and branch circuits. Bond conductors to chassis or fixed equipment.
C. All grounding conductors shall be bonded to multi-terminal ground bus at panelboard or other distribution equipment. Grouping of grounding conductors under a single lug is not acceptable.
D. Bond interior metal piping systems and metal air ducts to equipment ground conductors of pumps, fans, electric heaters, and air cleaners serving individual systems.
E. Bond structural steel and reinforcing steel in foundation footing to grounding electrode conductor. Bond steel together. Every corner column and every other column in between shall be connected to the ground ring.
F. Locate all grounding attachments away from areas subject to physical damage. Provide protective covering as required.
G. All separate grounding electrodes shall be bonded together to limit potential differences between them and between their associated wiring systems. This includes the power system, TVSS, telephone system, and system grounding electrodes.

3.02 CONNECTIONS

A. Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
   2. Make connections with clean bare metal at points of contact.
   3. Aluminum to steel connections shall be with stainless steel separators and mechanical clamps.
   4. Aluminum to galvanized steel connections shall be with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.

B. Use exothermic welded connections for connections to structural steel and for underground connections. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. For compression-type connections, use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

D. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

E. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.
F. Where insulated ground conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

G. Do not use flexible metal conduit and fittings as a grounding means. Pull a green wire in each piece of flexible conduit, and screw to conduit system with lugs at both ends.

3.03 FIELD QUALITY CONTROL

A. Use the fall-of-potential method as described in IEEE Standard 81 to measure the resistance of the following. Record the measurements and provide to the Engineer.
   1. The resistance between earth and each ground rod prior to interconnection with other ground rods.
   2. The resistance between earth and the counterpoise.
   3. The resistance of the grounding system at the grounding electrode connection to earth.
      a. Measure the ground resistance when there has been no precipitation for 5 days, without the soil being moistened by any means other than natural precipitation or natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance.
   4. Resistance shall be less than 15 ohms.

B. Perform continuity tests at all power receptacles to ensure the ground terminals are properly grounded to the facility ground network.

END OF SECTION
SECTION 26 05 29

SUPPORTING DEVICES

PART 1   GENERAL

1.01  WORK INCLUDED

A.  This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fasteners.

1.02  QUALITY ASSURANCE

A.  Electrical Component Standard: Components and installation shall comply with the National Electrical Code.

PART 2   PRODUCTS

2.01  MANUFACTURERS

A.  Subject to compliance with requirements, Slotted Metal Angle and U-Channel Systems shall be provided by Allied Tube & Conduit, American Electric, B-Line Systems, Inc., Unistrut Diversified Products, or approved equal.

B.  Subject to compliance with requirements, Conduit Sealing Bushings shall be provided by Bridgeport Fittings, Inc., Cooper Industries, Inc., Killark Electric Mfg. Co., O-Z/Gedney, Raco, Inc., Spring City Electrical Mgf. Co., Thomas & Betts Corp., or approved equal.

2.02  COATINGS

A.  Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be aluminum or hot-dip galvanized.

2.03  MANUFACTURED SUPPORTING DEVICES

A.  Raceway Supports: Raceways shall be supported with clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B.  Fasteners: Types, materials, and construction features as follows:

1.  Expansion Anchors: Carbon steel wedge or sleeve type.

2.  Toggle Bolts: All steel springhead type.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gauge steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.

2.04 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:
   1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
      a. 3-inch and smaller: 20-gauge.
      b. 4-inch to 6-inch: 16-gauge.
      c. over 6-inch: 14-gauge.
   2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
1. Conform to manufacturer’s recommendations for selection and installation of supports.

2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs. safety allowance in the strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Support parallel runs of horizontal raceways together on trapeze-type hangers.

5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. Space supports for raceway types not covered by the above in accordance with NEC.

7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.

8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

G. Sleeves: Install in concrete slabs and walls and all other fire rated floors and walls for raceways and cable installations. For sleeves through fire
rated wall or floor construction, apply UL listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with manufacturer’s recommendations.

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

END OF SECTION
SECTION 26 05 33

OUTLET AND JUNCTION BOXES

PART 1  GENERAL

1.01  WORK INCLUDED

A.  Wall and ceiling outlet boxes.
B.  Pull and junction boxes.

1.02  QUALITY ASSURANCE

A.  Listing and Labeling:  Provide outlet and junction boxes that are listed and labeled.
   1.  The term "listed and labeled":  As defined in the National Electrical Code, Article 100.
   2.  Listing and Labeling Agency Qualifications:  A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B.  Outlet and junction boxes and their installation shall comply with the requirements of the National Electrical Code.

PART 2  PRODUCTS

2.01  OUTLET AND JUNCTION BOXES

A.  Outlet and junction boxes shall be galvanized steel, 1-1/2" deep minimum by Raco, T&B/Steel City, Crouse Hinds or approved equal.

B.  Boxes for interior areas with exposed conduit shall be pressed steel and in exterior areas with exposed conduit shall be cast metal with threaded hubs, "FS" type.  Use galvanized steel for concealed boxes.

PART 3  EXECUTION

3.01  GENERAL

A.  Outlet and junction boxes in inaccessible ceiling areas shall be located no more than 6 inches from ceiling access panel or from removable recessed luminaire.

B.  Install boxes to preserve fire resistance rating of partitions and other elements, using UL listed fire stop materials and methods.

C.  Do not install flush mounted boxes back-to-back in walls; provide minimum six (6") inches separation.  Provide minimum twenty-four (24") inches separation in fire rated walls.
D. Do not fasten boxes to ceiling support wires.
E. Support boxes independently of conduit.
F. Bonding jumpers shall be used around knockouts.

3.02 OUTLET BOXES

A. Outlet boxes shall be securely anchored, set true, and plumb and no part of box shall extend beyond finished wall or ceiling. Flush mounted boxes shall be set to within 1/8" of finished wall and a plaster ring used to make cover flush with wall.

B. Select boxes according to intended use and type of outlet. Ceiling outlet boxes shall be four (4") inches octagon and 2-1/2" deep minimum. Use four (4") inches square boxes where required. All ceiling outlet boxes shall have a fixture stud of the no bolt, self-locking type if required to hang the fixture specified at the outlet.

C. Receptacle and switch boxes installed in concrete block walls not plastered shall be Steel City, Appleton, Raco Series No. 690 through No. 699, or approved equal masonry boxes of proper depth and gang required and specifically designed for this purpose. If more than two conduits enter box from one direction, 4" square boxes with square-cut device covers not less than one (1") inch deep specifically designed for this purpose, shall be used. Round edge plaster rings will not be acceptable for block walls. Sectional or gangable type outlet boxes will not be acceptable except in drywall construction.

D. Mount outlet boxes worked to nearest block course. Confirm ADA compliance.
E. Install blank device plates on outlet boxes left for future use.
F. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices. Confirm accessibility code compliance.

3.03 JUNCTION BOXES

A. Pull and junction boxes shall be sized in accordance with the National Electrical Code according to number of conductors in box or type of service to be provided. Minimum size is 4-11/16" square and 2-1/2" deep.

B. Pull boxes shall be provided where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than 100 feet or with bends exceeding 270 degrees shall have a pull box installed at a convenient intermediate location.

C. Install in locations as shown on Drawings and as required for splices, taps,
wire pulling, equipment connections, and compliance with regulatory requirements.

D. Install pull and junction boxes above accessible ceilings and in unfinished areas only.

3.04 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused box openings.

3.05 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

END OF SECTION
SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1  GENERAL

1.01  WORK INCLUDED

A. Extent and types of electrical identification are indicated herein and as follows:
   1. Operational instructions and warnings.
   2. Danger signs.
   3. Equipment/system identification signs.
   5. Power and control wiring identification.
   6. Terminal marking.
   7. Arc-flash warning.
   8. Panelboard Legends.

PART 2  PRODUCTS

2.01  MANUFACTURERS

A. Subject to compliance with requirements, identification products shall be provided by W.H. Brady Co., Ideal Industries, Inc., Panduit, T&B, or approved equal.

2.02  MATERIALS

A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option, but provide single selection for each application.

B. Cable/Conductor Identification Bands: Provide manufacturer's standard wrap-around type, vinyl-cloth, self-adhesive cable/conductor markers with either pre-numbered plastic coated type or write-on type with clear plastic self-adhesive cover flap, numbered to show circuit identification. Provide markers for all field control wiring.

C. Self-Adhesive Plastic Signs: Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings. Signs shall be of sizes suitable for application areas and adequate for visibility, with proper wording for each application (as examples: 208V, EXHAUST FAN or DANGER – HIGH VOLTAGE).
   1. Colors: Unless otherwise indicated or required by governing regulations, provide orange signs with black lettering.
D. Engraved Plastic-Laminate Signs: Provide three-layer engraving stock in sizes and thickness indicated, engraved with engraver’s standard letter style of sizes and wording indicated, black and white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
   1. Thickness: 1/16", for units up to 20 sq. in. or eight (8") length; 1/8" for larger units.
   2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

E. Underground Warning Tape: Provide four (4") inch wide detectable type, plastic, yellow warning tape with suitable warning describing type of cable/circuit over buried electrical lines.

203 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations, and other designations used in electrical identification work, with corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and working as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment.

PART 3 EXECUTION

301 APPLICATION AND INSTALLATION

A. General Installation Requirements:
   1. Coordination: Where identification is to be applied to surfaces, which require finish, install identification after completion of painting.
   2. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.
   3. Conduit Identification: Where electrical conduit is exposed in spaces with exposed mechanical piping which is identified by a color-coded method, apply color-coded identification on electrical conduit in a manner similar to piping identification. Except as otherwise indicated use orange as coded color for conduit.
   4. Equipment/System Identifications: Install engraved plastic-laminate sign on each disconnect and control cabinets. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide identification and warning signs for each unit of the following categories of electrical work.
      a. Electrical cabinets and enclosures.
      b. Panelboards
      c. Access panel/doors to electrical cabinets.
      d. Control stations.
      e. Disconnect switches.
B. Install signs at locations indicated or, where not otherwise indicated, at locations for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with stainless steel tamperproof fasteners.

C. Install danger signs on all disconnect and control cabinet exteriors.

D. Install danger and notice to disconnect power before removing or opening on all inner panels.

E. Install underground warning tape in accordance with the National Electrical Code.

END OF SECTION
SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICES

PART 1  GENERAL

1.01  WORK INCLUDED

A.  This section includes circuit breakers and fuses.

1.02  SUBMITTALS

A.  Provide manufacturer's product data for the following:
   1.  Circuit breakers
   2.  Enclosures
   3.  Fuses (Provide complete list of all fuses and the equipment where they are used.)
   4.  Shunt trips

B.  Provide maintenance data for products for inclusion in the Operating and Maintenance Manual.
   1.  Include a load current and overload relay heater list compiled by Contractor after motors have been installed. Arrange list to demonstrate selection of heaters to suit actual motor nameplate full load currents.

1.03  QUALITY ASSURANCE

A.  Listing and Labeling:  Provide overcurrent protective devices that are listed and labeled.
   1.  The term "listed and labeled":  As defined in the National Electrical Code, Article 100.
   2.  Listing and Labeling Agency Qualifications:  A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B.  Overcurrent protective devices and their installation shall comply with the requirements of the National Electrical Code.

C.  Circuit breakers shall comply with UL 489, NEMA AB 1, and NEMA AB 3.

D.  Fuses shall conform to NEMA FU 1.

PART 2  PRODUCTS

2.01  MANUFACTURERS

A.  Circuit Breakers:  Subject to compliance with requirements, provide products by Cutler-Hammer; General Electric Co.; Siemens Energy & Automation, Inc.; Square D Co.; or approved equal.
B. Fuses: Subject to compliance with requirements, provide products by Bussmann Mfg. Co., Littlefuse Co, Ferraz Shawmut, or approved equal.

2.02 MOLDED-CASE CIRCUIT BREAKERS

A. Circuit breakers shall be bolt-on only. Plug-in type circuit breakers are not permitted.

B. Circuit breakers shall be molded case, manually operated, trip-free, with inverse-time, thermal-overload protection, and instantaneous magnetic, short-circuit protection, as required. Circuit breakers shall be completely enclosed in a molded case, with the calibrated sensing element factory-sealed to prevent tampering.

C. Thermal-magnetic tripping elements shall be located in each pole of the circuit breaker and shall provide inverse-time-delay thermal overload protection and instantaneous magnetic short-circuit protection. On frame sizes larger than 100 amperes, the instantaneous magnetic tripping element shall be adjustable and accessible from the front of the breaker.

D. Breaker size shall be as required for the continuous current rating of the circuit. Breaker class shall be as required.

E. Interrupting capacity of the branch circuit breakers shall be sufficient to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Circuit breaker minimum interrupting capacities shall be as shown on drawings and shall conform to NEMA AB 3.

F. Multipole circuit breakers shall be of the common-trip type having a single operating handle and shall have a two-position on/off indication. Circuit breakers shall have temperature compensation for operation in an ambient temperature of 104 degrees F. Circuit breakers shall have root mean square (rms) symmetrical interrupting rating sufficient to protect the circuit being supplied. Interrupting ratings may have selective type tripping (time delay, magnetic, thermal, or ground fault).

G. Breaker body shall be of phenolic composition. Breakers shall be capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required.

H. Provide UL listed service entrance equipment when used for service disconnect.

I. Circuit breakers used for switching high intensity discharge lights or fluorescent lights shall be rated for that type of service.
2.03 ENCLOSED MOLDED-CASE CIRCUIT BREAKERS

A. Enclosed circuit breakers shall be thermal-magnetic, molded-case circuit breakers in surface-mounted, non-ventilated enclosures, conforming to the appropriate articles of NEMA 250 and NEMA AB 1.

2.04 FUSES

A. A complete set of fuses for all switches shall be provided. Fuses shall have a voltage rating not less than the circuit voltage.

B. Provide Class RK5 fuses for motor branch circuits.

C. Fuses shall be labeled showing UL class, interrupting rating, and time-delay characteristics, when applicable.

D. Fuse holders field-mounted in a cabinet or box shall be porcelain. Field installation of fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber shall not be used.

E. Provide a minimum of three (3) spare fuses of each size and type fuse installed.

F. Provide a complete list of all fuses and the equipment where they are used.

2.05 EQUIPMENT ENCLOSURES

A. Enclosures for equipment shall be in accordance with NEMA 250.

B. Equipment installed inside, clean, dry locations shall be contained in NEMA Type 1, general-purpose sheet-steel enclosures.

C. Equipment installed in wet locations shall be contained in NEMA Type 3R, rainproof, sheet-steel enclosures, constructed for outdoor use to protect against falling rain, sleet, and ice.

D. Ferrous-metal surfaces of electrical enclosures shall be cleaned, phosphatized, and painted with the manufacturer’s standard finish.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install overcurrent protective devices as indicated or required, in accordance with the manufacturer’s written instructions and with recognized industry practices to ensure that protective devices comply with requirements.
B. Coordinate with other work, including electrical wiring work, as necessary to interface installation of overcurrent protective devices.

C. Fasten circuit breakers without mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cables.

D. Install enclosed circuit breakers plumb with operating handle at five (5') feet above finished elevation.

E. Set field-adjustable circuit breakers for trip settings as indicated, subsequent to installation of devices.

F. Provide engraved plastic-laminate identification under the provisions of Section 26.05.53, "Electrical Identification" for enclosed circuit breakers and motor controllers.

3.02 FIELD QUALITY CONTROL

A. Prior to energization of overcurrent protective devices, test devices for continuity of circuitry and for short-circuits. Correct malfunctioning units, and then demonstrate compliance with requirements.

B. In the presence of the Owner or Owner’s Representative, test each device and demonstrate its working as specified.

END OF SECTION
PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

B. Section 019113 – General Commissioning Requirements

C. Section 220800 – Commissioning of Plumbing Systems

D. Section 230800 – Commissioning of HVAC

E. Commissioning Plan, dated [TBD]

1.02 SCOPE

A. Commissioning is an ongoing process and shall be performed throughout construction. Commissioning verifies that systems are operating in a manner consistent with the Contract Documents.

B. Following is a detailed list of equipment included in each commissioning activity:
   1. Emergency Lighting (Floor Level)
   2. Floor-Level Lighting Controls
   3. Fire Alarm System
   4. Occupancy Sensors
   5. Panelboards
   6. Switchboards
   7. Transformers

1.03 RESPONSIBILITIES

A. The Contractor shall be responsible for adhering to applicable code required procedures, standards and industry practices to ensure personal safety, the safety of others, and facility safety with regard to electrical equipment operation and testing. If there are procedures in the checklists or the functional performance tests which conflict with safety, the Contractor shall not proceed and shall notify the CxA immediately.

PART 2 PRODUCTS
2.01 MEANS OF ACCESS
A. The Contractor shall provide means for the CxA to access, observe and visually confirm proper operation of all equipment and systems. These means shall be in compliance with all OSHA and job-site safety regulations.

2.02 TEST EQUIPMENT
A. The Contractor shall provide the necessary equipment to fully test the commissioned systems as defined in the Contract Documents and as defined in the functional performance test procedures to be provided by the CxA.

B. The test equipment shall meet the following minimum requirements.
   1. All test equipment shall be in good mechanical and electrical condition.
   2. Field test metering used to check power system meter calibration will be more accurate than the instrument being tested.
   3. Accuracy of metering in test equipment shall be appropriate for the test being performed.
   4. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and the tested equipment.

C. Calibration
   1. Calibration of all test equipment shall be current.
   2. Calibration accuracy shall be traceable to National Institute of Standards and Technology (NIST).
   3. Test equipment shall be calibrated in accordance with the following schedule.
      a. Field instruments
         1) Analog – At least every 6 months
         2) Digital – At least every 12 months
      b. Leased Specialty Equipment – At least every 12 months
   4. Dated calibration labels shall be visible on all test equipment.
   5. Calibration records shall be provided for all test equipment used in the project.

PART 3 EXECUTION
3.01 START-UP PLAN
A. The Contractor shall perform start-up testing for each piece of equipment to ensure that the equipment and systems are properly installed and ready for
operation, so that functional performance testing may proceed without delays.

B. The Contractor shall prepare a start-up plan for each piece of equipment. This plan shall be submitted to the CxA for review and comment. The start-up plan shall consist, at a minimum of the following:
   1. The manufacturer’s standard start-up and check out procedures copied from the installation manuals.
   2. Checklists and procedures with specific spaces for recording and documenting the inspection of each procedure and a summary block for deficiencies and explanations.

C. Two (2) weeks prior to expected start-up for a piece of equipment, the Contractor shall notify the Owner and the CxA in writing. The execution of the start-up plan shall be directed and performed by the Contractor. The CxA and/or the Owner may be present for the start-up of the first unit of each type of equipment.

D. The Contractor shall submit the completed equipment checklists to the CxA for review. The Contractor shall note all non-compliance items on these checklists. The Contractor shall notify the CxA when outstanding items have been corrected.

E. The Contractor shall complete the start-up plan and resolve or correct all issues resolved before functional testing may begin.

3.02 EQUIPMENT CHECKLISTS

A. Equipment checklists, provided by the CxA, shall be completed by the Contractor on CxAloy. The following checklists will be provided:
   1. Equipment Pre-Functional Checklist

3.03 FUNCTIONAL PERFORMANCE TESTS

A. The Contractor shall provide all documentation as requested to the CxA for development of functional performance testing procedures. This documentation shall include, at a minimum, manufacturer installation, start-up, operation and maintenance procedures. The CxA may request further documentation as necessary for the development of functional performance tests.

B. The Contractor shall review the functional performance test procedures developed by the CxA.
   1. The Contractor shall respond in writing to the CxA regarding the acceptability of the proposed test procedures.
   2. The Contractor shall note any necessary modifications to the procedures due to the actual equipment/systems or safety concerns and shall submit these to the CxA for consideration.

C. The Contractor shall place equipment and systems into operation and continue the operation as required during each working day of the testing activities.
D. The Contractor shall accomplish the functional performance testing of equipment based on procedures developed by the CxA and as reviewed by the Contractor.
   1. The Contractor shall provide skilled technicians to operate the systems during functional performance testing.
   2. The Contractor shall correct any deficiencies as identified during testing and retest equipment as required.

E. Functional performance testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of the system at the discretion of the CxA and the Contractor.

F. Upon successful completion of all functional performance tests, the Contractor(s) shall perform Integrated Systems Testing. The testing shall document and verify the proper response of all Division 26 systems to all potential utility and emergency power operating and failure scenarios.

END OF SECTION
## Panelboard Check Sheet

### System/Unit Identifier:

<table>
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<tr>
<th>ITEM</th>
<th>PANEL</th>
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<tr>
<td>Room sprinkler</td>
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<tr>
<td>Pipes above panel</td>
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<tr>
<td>NEC code space</td>
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<tr>
<td>Conduits secured</td>
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<tr>
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<td>Spare breakers off</td>
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### Measurements

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**Owner's Project Number:** 166/005-01-2014

**Institution or Campus:** ETSU

**Building:** DP Culp Center

**Installer:**

**Tests run by:**

**Date:**

**Page** of **of**
# SECTION 26 08 13
## POWER CIRCUIT CHECK SHEET

<table>
<thead>
<tr>
<th>Floor</th>
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<th>Ckt.</th>
<th>Device</th>
<th>Volts</th>
<th>Wiring</th>
<th>GFI/ARC msec/mA</th>
<th>V-Drop @ Load %</th>
<th>Imp/ohms Hot Leg</th>
<th>Coments</th>
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Owner's Project Number: 166/ 005-01-2014
Institution or Campus: ETSU
Building: DP Culp Center
Installer:

System/Unit Identifier:

Location:

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Power Circuit Check Sheet
26 08 13 - 1

June 2011 OFD s260813
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### SECTION 26 08 30

**GENERATOR TESTING PROCEDURES FORM**

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#### Step by Step Detailed Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Procedure</th>
<th>Expected Result</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ATS Breaker&lt;br&gt; Open ATS Breaker&lt;br&gt; Close ATS Breaker &amp; put ATS Sw. to Auto</td>
<td>Verify power off at all loads on emergency power.&lt;br&gt; Verify all loads have power.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Generator Cold Start&lt;br&gt; Open normal power breaker &amp; immediately connect full load bank load capacity to ATS units. (This connection must be made before the generator engine is up to speed &amp; transfer to emergency power is complete. Observe the systems performance &amp; record the date using a Power Line Disturbance Monitor to monitor transient responses. Compare to specifications.</td>
<td>Time delay from power failure to engin start should be within sec.&lt;br&gt; Cranking time until prime mover starts and runs should be within sec.&lt;br&gt; Time until engine-generator is at proper voltage and frequency should be within sec.&lt;br&gt; Total time from power failure until ATS switch is on emergency power should be within sec.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Repeat Generator Cold Start&lt;br&gt; Open normal power breaker &amp; immediately connect full load bank load capacity to ATS units. (This connection must be made before the generator engine is up to speed &amp; transfer to emergency power is complete. Observe the systems performance &amp; record the date using a Power Line Disturbance Monitor to monitor transient responses. Compare to specifications.</td>
<td>Time delay from power failure to engin start should be within sec.&lt;br&gt; Cranking time until prime mover starts and runs should be within sec.&lt;br&gt; Time until engine-generator is at proper voltage and frequency should be within sec.&lt;br&gt; Total time from power failure until ATS switch is on emergency power should be within sec.</td>
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### Step by Step Detailed Procedure

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<th>Step</th>
<th>Procedure</th>
<th>Expected Result</th>
<th>Observations</th>
</tr>
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<tbody>
<tr>
<td>4. Phase Testing</td>
<td>Record voltage &amp; amperage of each phase &amp; frequency using analyzer, not generator gages; engine temperature, oil pressure &amp; battery charge rate at 5 minute intervals for a period of one hour. Measure the temp. of all generator &amp; ATS connections using a laser guided infrared temperature meter.</td>
<td>Voltage V</td>
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<td></td>
<td>Coolant Temp. F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oil Pressure PSI</td>
<td></td>
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<td></td>
<td></td>
<td>Battery Charge Rate</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>ATS Contacts Input Temp. F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATS Contacts Onput Temp. F</td>
<td></td>
</tr>
<tr>
<td><strong>ABOVE VALUES PERFORMANCE CRITERIA FOR ABOVE VALUES PERFORMANCE CRITERIA FOR TABLE IN SECTION 26 08 32</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Return to Normal Power</td>
<td>Disconnect Load Bank from ATS, before transfer back to normal power. Restore Normal Power Breaker and record delay to normal power transfer using PDM. Record neutral delay time by recording V differential between EGP &amp; UP at the time of the transfer back to normal power using PDM.</td>
<td>Time delay to return normal power should be within sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neutral delay time should be within sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generator Power to Utility Power, V should be 0.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engine continues to run &amp; cool down time should be min.</td>
<td></td>
</tr>
<tr>
<td>6. Step Load Testing</td>
<td>After cool-down timer has expired, start the generator by opening the ATS normal input power breaker. With the emergency bus energized perform the step load test verify that volts &amp; HZ stay within specified range during transition &amp; HZ stability (rate of change) is acceptable using PDM.</td>
<td>Step</td>
<td>Voltage V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-25%</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-50%</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-100%</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100-50%</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100-25%</td>
<td>V</td>
</tr>
</tbody>
</table>
### Step by Step Detailed Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Expected Result</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>Temperature on Load Bank</td>
<td>Connect full load bank to ATS. Maintain power flow for 15 min and then take temperature readings with infrared meter looking for hot spots.</td>
<td>There should be no significant diff in temp between Phs.</td>
</tr>
<tr>
<td>8.</td>
<td>Temperature on Utility</td>
<td>Transfer load to Utility source. Maintain power flow for 15 min and then take temperature readings with infrared meter looking for hot spots.</td>
<td>There should be no significant diff in temp between Phs.</td>
</tr>
<tr>
<td>9.</td>
<td>ATS Test Switch</td>
<td>Operate the ATS test switch &amp; verify that generator starts and emergency power sequence is initiated. Bypass the return to normal timer to accelerate the test sequence.</td>
<td>Generator should start and emergency power sequence initiate. Verify that total time to emergency power meets that specified (see procedure 2).</td>
</tr>
<tr>
<td>10.</td>
<td>Safety Interlocks ATS</td>
<td>Operate the ATS and controls in a deranged manner to create an alarm condition.</td>
<td>Alarms should be generated and emergency power remains off.</td>
</tr>
<tr>
<td>11.</td>
<td>Alarms ATS</td>
<td>Simulate all alarms, alarm contact operation and remote enunciator operation by jumping across alarms.</td>
<td>All alarms are properly annunciated in the remote panel.</td>
</tr>
<tr>
<td>Step by Step Detailed Procedure</td>
<td>Expected Result</td>
<td>Observations</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td><strong>12. ATS Digital Readouts</strong></td>
<td>Check calibration of ATS digital readouts of frequency, current and volts against a calibrated instrument.</td>
<td>ATS should be within tolerances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage V</td>
<td>Actual V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ampereage A</td>
<td>Actual A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency HZ</td>
<td>Actual HZ</td>
<td></td>
</tr>
<tr>
<td><strong>13. UPS with Load Bank Off</strong></td>
<td>Connect the UPS to a load bank and leave the load bank off. Operate the UPS for 1/2 hour without load while monitoring UPS output with Power Line Disturbance Monitor and Load Profiler. Take a waveform and load profiler snapshot. Observe the variations in voltage, frequency, total harmonic distortion (THD), and the waveform deviation.</td>
<td>UPS values should be within tolerances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage V</td>
<td>Actual V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency HZ</td>
<td>Actual HZ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>THD &lt; 5%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waveform Deviation</td>
<td>Minimal</td>
<td></td>
</tr>
<tr>
<td><strong>14. UPS with Load Bank at 50%</strong></td>
<td>Bring the UPS to its 50% kW rating (balanced load) in 25% increments. Operate the UPS for 1 hour and monitor UPS output</td>
<td>UPS values should be within tolerances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage V</td>
<td>Actual V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency HZ</td>
<td>Actual HZ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>THD &lt; 5%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waveform Deviation</td>
<td>Minimal</td>
<td></td>
</tr>
</tbody>
</table>
### Step by Step Detailed Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Expected Result</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td>UPS with Load Bank at 100% Bring load bank load up to 100% of rated kW (balanced load) and monitor UPS output for 2 continuous hours.</td>
<td>UPS values should be within tolerances</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Voltage Specified V Actual V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequency Specified HZ Actual HZ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>THD Specified &lt; 5% Actual %</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waveform Deviation Specified Minimal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Record all electrical distribution systems connection temperatures using an infrared meter.</td>
<td>There should be no significant diff in temp between Phs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phase 1 F Phase 2 F Phase 3 F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F F F</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>UPS Step Load Test UPS shall be subjected to 3 consecutive step load tests. Monitor and record the UPS performance for Voltage Overshoot (VO), Frequency Overshoot (FO), Total Harmonic Distortion (THD) and Waveform Deviation. The generator should power load and not transfer to battery. The UPS will be monitored and waveform deformation/harmonic content. Each of the four step tests shall be performed at 1 min. intervals until 3 repitions have been completed.</td>
<td>Specified VO, V Actual VO, V THD, % Wave</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0%/15sec 25%/15sec 0%/15sec 50%/15sec 0%/15sec 100%/15sec 50%/15sec 100%/15sec 50%/15sec 125%/15sec</td>
<td></td>
</tr>
</tbody>
</table>

*(16. ups Step Load test continued on next page)*
(16. ups Step Load test continued from previous page) Step VO, V FO, HZ THD, % Wave
UPS shall be subjected to 3 consecutive step load tests. Monitor and record the UPS performance for Voltage Overshoot (VO), Frequency Overshoot (FO), Total Harmonic Distortion (THD) and Waveform Deviation. The generator should power load and not transfer to battery. The UPS will be monitored and waveform deformation/harmonic content. Each of the four step tests shall be performed at 1 min. intervals until 3 repitions have been completed.

<table>
<thead>
<tr>
<th>Step</th>
<th>VO, V</th>
<th>FO, HZ</th>
<th>THD, %</th>
<th>Wave</th>
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<tbody>
<tr>
<td>Specified</td>
<td></td>
<td></td>
<td>&lt; 5.0</td>
<td>Minimal</td>
</tr>
<tr>
<td>0%/15sec</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%/15sec</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>0%/15sec</td>
<td></td>
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<tr>
<td>50%/15sec</td>
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<tr>
<td>0%/15sec</td>
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<tr>
<td>100%/15sec</td>
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<tr>
<td>50%/15sec</td>
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<tr>
<td>100%/15sec</td>
<td></td>
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<td></td>
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<tr>
<td>50%/15sec</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>125%/15sec</td>
<td></td>
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<tr>
<td>0%/15sec</td>
<td></td>
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<tr>
<td>25%/15sec</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0%/15sec</td>
<td></td>
<td></td>
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<tr>
<td>50%/15sec</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0%/15sec</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>100%/15sec</td>
<td></td>
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</tr>
<tr>
<td>50%/15sec</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>100%/15sec</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>50%/15sec</td>
<td></td>
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<tr>
<td>125%/15sec</td>
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</tr>
<tr>
<td>100%/5min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125%/5min</td>
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<tr>
<td>Step by Step Detailed Procedure</td>
<td>Expected Result</td>
<td>Observations</td>
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<tr>
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<tr>
<td>17.  Grounding</td>
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</tr>
<tr>
<td>Verify connections &amp; grounding is in compliance with NEC, especially grounding &amp; bonding of UPS &amp; generator.</td>
<td>Wiring &amp; grounding are in compliance with NEC.</td>
<td></td>
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<tr>
<td>18. UPS with Load Bank at 100%</td>
<td></td>
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</tr>
<tr>
<td>With the UPA loaded as stated in the previous test, the UPS INTERNAL manual maintenance bypass switch will be manually operated 2 consecutive times transferring the load between UPS power, alternate power, and back to UPS power. Switching shall occur in 2 minute intervals. Verify that specified voltage dynamic regulation is met during switching.</td>
<td>UPS values should be within the following.</td>
<td>Specified</td>
<td>Actural</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>THD</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Waveform</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Deviation</td>
<td></td>
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</tr>
<tr>
<td>19. UPS with Load Bank at 100%</td>
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<td></td>
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</tr>
<tr>
<td>With the UPA loaded as stated in the previous test, the UPS EXTERNAL manual maintenance bypass switch will be manually operated 2 consecutive times transferring the load between UPS power, alternate power, and back to UPS power. Switching shall occur in 2 minute intervals. Verify that specified voltage dynamic regulation is met during switching.</td>
<td>UPS values should be within the following.</td>
<td>Specified</td>
<td>Actural</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>THD</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Waveform</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Deviation</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Step by Step Detailed Procedure</td>
<td>Expected Result</td>
<td>Observations</td>
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<td>---------------------------------</td>
<td>-----------------</td>
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<td></td>
</tr>
<tr>
<td>20. Safety Interlocks UPS</td>
<td>Operate the UPS &amp; controls in a deranged manner to create alarm condition.</td>
<td>Alarms should be generated and emergency power will remain off.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Alarms UPS</td>
<td>Simulate all alarms, alarm contact operation and remote enunciation operation by jumping across alarms.</td>
<td>All alarms are properly annunciated at the remote panel.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. UPS Digital Readouts</td>
<td>Check calibration of UPS digital readouts of frequency, current and volts against a calibrated instrument.</td>
<td>UPS should be within tolerances</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specified</td>
<td>Actual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ampereage</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>HZ</td>
<td>HZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. UPS with Load Bank at 100%</td>
<td>With the UPS loaded at 100%, UPS input power will be interrupted to simulate a power failure. The UPS output will be monitored &amp; recorded for RMS values, waveform deformation/harmonic content. The roll-off of battery potential shall be monitored, recorded and compared to the battery run time spec. All accessible battery terminations will be checked for temperature variations with an infrared meter.</td>
<td>UPS values should be within these tolerances.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specified</td>
<td>Actual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMS</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>A/sec</td>
<td>A/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>THD</td>
<td>&lt; 5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waveform Deviation</td>
<td>Minimal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPS shutdown at low battery string volts</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Step by Step Detailed Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>24. Preparation</strong></td>
<td>Reconnect power to the UPS and with 100% output load on the UPS system and full battery recharged current (wait approx. 5 minutes to allow batteries to charge to support load during loss of power).</td>
<td>Generator values should be within following tolerances. Specified Actural Load &lt; 100% Load %</td>
<td></td>
</tr>
<tr>
<td><strong>25. Emergency Power Test</strong></td>
<td>Test the function of all loads on emergency power including UPS loads. Open the circuit breaker serving the ATS to simulate a power failure on the feeder serving the ATS &amp; Backup Power Distribution. Verify that proper power is delivered to each device listed in the emergency panel schedules and that equipment directly wired function properly. Record generator output with the Powerline Disturbance Monitor and a Load Profiler.</td>
<td>UPS loads should properly operate off the generator and not transfer to battery. All emergency lights ON. All emergency receptacles powered. Fire Alarm system powered. Specialty systems powered. HVAC &amp; Controls powered.</td>
<td></td>
</tr>
<tr>
<td>Step by Step Detailed Procedure</td>
<td>Expected Result</td>
<td>Observations</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>26 Emergency Power Test</td>
<td>Initiate a building smoke detector. Fire alarm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialty System</td>
<td>Initiate a security system alarm. Security system should work properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Initiate a HVAC alarm. HVAC monitoring system should work properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check telecom system. Telecom system works properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test elevator recall. Elevator works properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor UPS charging system</td>
<td>UPS charging properly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SYSTEM THAT HAVE OFF SITE MONITORING VERIFY THAT CORRECT SIGNALS ARE SENT AND RECEIVED.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Emergency Power</td>
<td>Verify the following functions by causing the alarm, recording the time and having the monitoring company fax a copy of the alarm condition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Including UPS Monitored Alarms</td>
<td>Simulate an electrical failure or malfunction</td>
<td>Electrical failure alarm. Response Time:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simulate a UPS switch detection.</td>
<td>Power switched alarm. Response Time:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simulate a HVAC condition alarm.</td>
<td>HVAC alarm. Response Time:</td>
<td></td>
</tr>
</tbody>
</table>
### Generator Testing Findings Form

**Owner's Project Number:** 166/005-01-2014

**Institution or Campus:** ETSU

**Building:** DP Culp Center

**Installer:**

**Manufacturer:**

**Model:**

**Location:**

**Serial Number:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Ambient Temp F</th>
<th>Voltage</th>
<th>Amperage</th>
<th>Frequency</th>
<th>Coolant Temp F</th>
<th>Oil Press</th>
<th>Battery Charge Rate</th>
<th>ATS Input Temp F</th>
<th>ATS Output Temp F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P1</td>
<td>P2</td>
<td>P3</td>
<td>P1</td>
<td>P2</td>
<td>P3</td>
<td>P1</td>
<td>P2</td>
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<td>0 min</td>
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<tr>
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SECTION 26 22 00

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SCOPE

A. The Contractor shall furnish and install single-phase and three-phase general purpose individually mounted dry-type transformers of the two-windings type, self-cooled as specified herein, and as shown on the contract drawings.

1.02 REFERENCES

A. The transformers and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI, NEMA and UL.

B. Transformers shall meet the requirements of federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment".

1.03 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:
   1. Outline dimensions and weights
   2. Technical certification sheet
   3. Transformer ratings including:
      a. kVA
      b. Primary and secondary voltage
      c. Taps
      d. Basic impulse level (BIL) for equipment over 600 volts
      e. Design impedance
      f. Insulation class and temperature rise
      g. Sound level.
   4. Product data sheets

1.04 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes.
   1. Final as-built drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process
   2. Connection diagrams
   3. Installation information
   4. Seismic certification and equipment anchorage details as specified
1.05 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 REGULATORY REQUIREMENTS

A. All transformers shall be UL listed and bear the UL label.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer’s instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton, Square-D, General-Electric, or Siemens products

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Other manufacturers will be considered, provided their products meet the requirements of the documents.

2.02 RATINGS

A. The kVA and voltage ratings shall be as indicated on the drawings.

B. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.
C. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

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<thead>
<tr>
<th>KVA Range</th>
<th>Decibels (dB)</th>
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<td>0 to 9</td>
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2.03 CONSTRUCTION – GENERAL PURPOSE TRANSFORMERS

A. Insulation Systems
1. Transformer insulation system shall be as follows:
   a. Less than 15 kVA: 185 degrees C insulation system with 115 degree C rise, encapsulated design; 15 kVA and above: 220 degree C insulation system with 115 degree C rise, ventilated design.
2. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 degrees C maximum ambient, and a 24-hour average ambient of 30 degrees C
3. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635

B. Core and Coil Assemblies
1. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade copper with continuous wound construction
2. On three-phase units rated 15 kVA and below the core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level
3. On three-phase units rated 15 kVA and above the core and coil assembly shall be impregnated with non-hydroscopic, thermostetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads

C. Taps
1. Three-phase transformers rated 15 through 500 kVA shall be provided with six 2-1/2% taps, two above and four below rated primary voltage
2. All single-phase transformers, and three-phase transformers rated below 15 kVA and above 500 kVA, shall be provided with the manufacturer’s standard tap configuration.

D. Electrostatic Shielding
   1. Where shown on the drawings, provide shielded isolation transformers (K-13) with an electrostatic shield consisting of a single turn of aluminum placed between the primary and secondary winding and grounded to the housing of the transformer.

2.04 ENCLOSURE – GENERAL PURPOSE TRANSFORMERS

A. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be grounded to the enclosure.

B. On three-phase units rated 15 kVA and below the enclosure construction shall be encapsulated, totally enclosed, non-ventilated, NEMA 3R, with lifting eyes.

C. On three-phase units rated 15 kVA and above the enclosure construction shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt.

2.05 FINISH

A. Enclosures shall be finished with ANSI 61 color, weather-resistant enamel.

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
   1. Ratio tests at the rated voltage connection and at all tap connections
   2. Polarity and phase relation tests on the rated voltage connection
   3. Applied potential tests
   4. Induced potential test
   5. No-load and excitation current at rated voltage on the rated voltage connection

3.02 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer’s recommendations and the contract drawings.
B. Provide vibration isolation for all new transformers. 45kVA and below may be neoprene rubber type, with 75kVA and above being full spring type isolators.

3.03 FIELD ADJUSTMENTS

A. Adjust taps to deliver appropriate secondary voltage.

3.04 FIELD TESTING

A. Measure primary and secondary voltages for proper tap settings.

END OF SECTION
SECTION 26 24 00

MECHANICAL EQUIPMENT AND CONTROLS

PART 1  GENERAL

1.01  RELATED DOCUMENTS

A.  General provisions of contract, including general and supplementary conditions and general requirements apply to work specified in this section.

PART 2  PRODUCTS

2.01  STARTERS

A.  All starters for Division 22 and 23 package mechanical equipment will be furnished by Division 22 and 23, but installed and connected by Division 26

2.02  CONTROL WIRING

A.  All control wiring for mechanical equipment shall be provided in conduit under each respective division. Control components for mechanical equipment will be furnished and installed by Division 22 and 23.

2.03  POWER WIRING

A.  All power wiring at 120, 208, 277 and 480 volts shall be provided by Division 26.

PART 3  EXECUTION

3.01  INSTALLATION

A.  Coordinate electrical power connection requirements with Mechanical Contractor. Where power requirements differ from drawing design requirements, Engineer shall be notified in writing. Contractor shall be given clarification and installation requirements prior to installation of the portion of work. Cost of equipment and labor for improperly installed electrical connections not coordinated and approved by Engineer and Mechanical Contractor shall be incurred by the Electrical Contractor and shall not constitute a reason for an extra charge because of any rework.

END OF SECTION
SECTION 26 24 16

PANELBOARDS

PART 1  GENERAL

1.01  SCOPE

A. The Contractor shall furnish and install the panelboards as specified and as shown on the contract drawings.

1.02  REFERENCES

A. The panelboards and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows:
   1. UL 67 – Panelboards
   2. UL 50 – Cabinets and boxes
   3. NEMA PB1
   5. Circuit breaker – Type I class I
   6. Fusible switch – Type II class I

1.03  SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:
   1. Breaker layout drawing with dimensions indicated and nameplate designation
   2. Component list
   3. Conduit entry/exit locations
   4. Assembly ratings including:
      a. Short-circuit rating
      b. Voltage
      c. Continuous current
   5. Cable terminal sizes
   6. Product data sheets

B. Where applicable, the following additional information shall be submitted to the Engineer:
   1. Key interlock scheme drawing and sequence of operations

1.04  SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process
   2. Installation information
1.05 QUALIFICATIONS
   A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
   B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
   C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
   D. The panelboards shall be UL labeled.

1.07 DELIVERY, STORAGE AND HANDLING
   A. Equipment shall be handled and stored in accordance with manufacturer’s instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.08 OPERATION AND MAINTENANCE MANUALS
   A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Eaton, Square-D, General Electric, and Siemens
      The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Other manufacturers will be considered, provided their products meet the requirements of the documents.

2.02 RATINGS
   A. Panelboards rated 240 Vac or less shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 10,000 amperes RMS symmetrical.
   B. Panelboards rated 480 Vac shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 14,000 amperes RMS symmetrical.
C. Panelboards shall be labeled with a UL short-circuit rating. When series ratings are applied with integral or remote upstream devices, a label or manual shall be provided. It shall state the conditions of the UL series ratings including:
   1. Size and type of upstream device
   2. Branch devices that can be used
   3. UL series short-circuit rating

2.03 CONSTRUCTION

A. Interiors shall be completely factory assembled. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.

B. Trims for branch circuit panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi flush cylinder lock and catch assembly. Door-in-door trim shall be provided. Both hinged trim and trim door shall utilize three point latching. No tools shall be required to install or remove trim. Trim shall be equipped with a door-actuated trim locking tab. Equip locking tab with provision for a screw such that removal of trim requires a tool, at the owner’s option. Installation shall be tamper resistant with no exposed hardware on the panelboard trim.

C. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible.

D. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.

E. A directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.

F. All locks shall be keyed alike.

2.04 BUS

A. Main bus bars shall be copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.

B. A system ground bus shall be included in all panels.

C. Full-size (100%-rated) insulated neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
2.05 BRANCH CIRCUIT PANELBOARDS

A. The minimum short-circuit rating for branch circuit panelboards shall be as specified herein or as indicated on the drawings. Panelboards shall be series rated. Panelboards shall be Eaton type Pow-R-Line 1a, Pow-R-Line 2a or Pow-R-Line 3a.

B. Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.

C. Circuit breakers shall be thermal-magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100-ampere frame and through 100-ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as type SWD for lighting circuits.
   1. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management, and control system (EMCS) panels and fire alarm panels.

D. Circuit breakers shall have a minimum interrupting rating of 10,000 amperes symmetrical at 240 volts, and 14,000 amperes symmetrical at 480 volts, unless otherwise noted on the drawings.

2.06 DISTRIBUTION PANELBOARDS – CIRCUIT BREAKER TYPE

A. Distribution panelboards with bolt-on devices contained therein shall have interrupting ratings as specified herein or indicated on the drawings. Panelboards shall be series rated. Panelboards shall be Eaton type Pow-R-Line 3a or Pow-R-Line 4B. Panelboards shall have molded case circuit breakers as indicated below.

B. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.

C. Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.

2.07 ENCLOSURE

A. Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.

B. Enclosures shall be provided with blank ends.

C. Where indicated on the drawings, branch circuit panelboards shall be column width type.
2.08 NAMEPLATES

A. Provide an engraved nameplate for each panel section.

2.09 FINISH

A. Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 61 paint applied.

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

3.02 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer’s recommendations and the contract drawings.

END OF SECTION
SECTION 26 27 01

ELECTRICAL SERVICE ENTRANCE

PART 1 GENERAL

1.01 WORK INCLUDED

A. Electrical Power Service System

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish service entrance conduit and cable and miscellaneous hardware required.

PART 3 EXECUTION

3.01 SERVICE

A. System is for the most part existing and commences at the existing pad-mounted transformer secondary and continues through the main switchboard, feeder circuits, panelboards, and branch circuits to wiring devices, appliances, apparatus, and other utilization equipment.

B. The existing service is 480Y/277 volts, three (3) phase, four (4) wire, solidly ground wye, from an existing pad-mounted transformer at the back of the building (South). Coordinate any outages or service modifications with JCPB and ETSU.

C. Metering is existing at the transformer secondary bushings.

END OF SECTION
SECTION 26 27 26

WIRING DEVICES AND PLATES

PART 1  GENERAL

1.01  WORK INCLUDED

A.  Switches
B.  Receptacles
C.  Plates

1.02  QUALITY ASSURANCE

A.  Listing and Labeling:  Provide wiring devices and plates that are listed and labeled.
   1.  The term "listed and labeled":  As defined in the National Electrical Code, Article 100.
   2.  Listing and Labeling Agency Qualifications:  A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B.  Wiring devices and plates and their installation shall comply with the requirements of the National Electrical Code.

PART 2  PRODUCTS

2.01  SWITCHES

A.  Switches shall be toggle, quiet-type with totally enclosed bodies of thermo-plastic and mounting strap.

B.  Switches shall be rated for 20 amps, 277 volts AC.  Switches shall be specification grade Hubbell, P&S, Leviton, Cooper Wiring Devices, or approved equal.

2.02  RECEPTACLES

A.  Receptacles shall be general purpose, heavy duty, duplex receptacles made of thermoplastic supported on a metal mounting strap in accordance with NEMA WD 1.  Receptacles shall be 20 amp, 125 volt, specification grade Cooper Wiring Devices, Hubbell, Leviton, P&S.

B.  Ground fault circuit interrupter receptacles shall be the "feed-through" type rated to protect 20 amps.  Receptacles shall be specification grade duplex receptacles with almond impact-resistant nylon face with test and reset buttons.
1. 20 Amp, 125 Volt: Cooper Wiring Devices, Hubbell, Leviton, P&S, or approved equal.

C. Special Receptacles: As indicated on Drawings, and including USB Charging type receptacles in public areas, corridors, and conference rooms.

2.03 PLATES

A. Provide UL listed, one-piece device plates to suit the devices installed.

B. For metal outlet boxes, plates on unfinished walls shall be of zinc-coated sheet steel or cast-metal having round or beveled edges.

C. Plates on finished walls shall be nylon or thermoplastic, mid-size, unless noted otherwise. Plates in the kitchens/food service areas shall be stainless steel.

D. Plates shall be same color as receptacle or toggle switch with which they are mounted. Screws shall be machine-type with countersunk heads in color to match finish of plate.

E. Plates installed in wet locations shall be gasketed and UL listed for “wet locations” as per NEC 406.8 (B).

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide proper size outlet boxes for all wiring devices in accordance with Section 26.05.33, “Outlet and Junction Boxes.”

B. Install switches forty-eight (48") inches above finished floor on lock side and clear of door frame a minimum of three (3") inches unless otherwise noted. Prior to rough-in, coordinate with architectural drawings to determine lock side of door.

C. All switches shall be made by the same manufacturer.

D. Where two or more snap switches are to be installed at the same location, they shall be mounted in one-piece ganged switch boxes, with at gang cover plate.

E. Combination snap switch and single or duplex receptacles shall be mounted in two-gang switch box with one-piece device plate.

F. Receptacles shall be mounted 18" above finished floor unless otherwise noted.

G. All wiring devices shall be mounted in accordance with accessibility code requirements.
H. The color of all devices and plates shall be selected by the architect.

END OF SECTION
SECTION 26 28 13

DISCONNECT SWITCHES

PART 1  GENERAL

1.01  WORK INCLUDED

A.  Fused Disconnect Switches

1.02  SUBMITTALS

A.  Provide product data showing switch’s ratings and enclosure type

1.03  QUALITY ASSURANCE

A.  Listing and Labeling:  Provide disconnect switches that are listed and labeled.
   1.  The term "listed and labeled":  As defined in the National Electrical Code, Article 100.
   2.  Listing and Labeling Agency Qualifications:  A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B.  Disconnect switches and their installation shall comply with the requirements of the National Electrical Code.

PART 2  PRODUCTS

2.01  MANUFACTURERS

A.  Switches shall be Eaton, or approved equal.  Examples are Square D, General Electric, Siemens Energy & Automation.

2.02  MATERIALS

A.  Use heavy-duty type for 600 volt switches.  Switches shall have quick make, quick break, load interrupter, enclosed knife switch manufactured to the requirements of NEMA KS 1.

B.  All switches shall have externally operable handles with interlocking covers to prevent opening front cover with switch in the ON position and have provisions for multiple padlocks in the OFF position.

C.  Provide equipment ground lug in each switch.

D.  Provide NEMA 1 enclosures for interior installations, unless otherwise noted.
E. Provide NEMA 3R enclosures for exterior installations or in wet locations, unless otherwise noted.

F. Provide fuses as per equipment manufacturer recommendation, dual-element, time-delay, current limiting, with blown fuse indicator site glass.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Provide safety switches sized as indicated on the Drawings.

B. Mount individually enclosed switches plumb and level with top four (4') feet above floor or grade, unless otherwise noted.

C. Provide a set of fuses in fusible disconnect switches, as per equipment manufacturer recommendations.

3.02 IDENTIFICATION

A. Identify disconnect switches in accordance with Section 26 05 53, "Electrical Identification."

END OF SECTION
**SECTION 26 32 13**

**GENERATOR SET**

**PART 1  GENERAL**

1.01 SCOPE OF WORK

A. It is the intent of this specification to secure an engine-driven generator set that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.

B. Any and all substitutions shall be subject to the approval of the engineer.

C. The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.

D. The equipment shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.

E. The equipment shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.

1.02 GENERAL REQUIREMENTS

A. It is the intent of this specification to secure a generator set system that has been tested during design verification, in production, and at the final job site. The generator set will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.

B. All equipment shall be new and of current production by a national firm that manufactures the generator sets and controls, transfer switches, and switchgear, and assembles the generator sets as a complete and coordinated system. There will be one-source responsibility for warranty, parts, and service through a local representative with factory-trained servicemen.
1.03 SUBMITTAL

A. The submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.

1.04 CODES AND STANDARDS

A. The generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed. The generator shall be EPA Certified.

B. The generator set shall conform to the requirements of the following codes and standards:
   2. EN50082-2, Electromagnetic Compatibility-General Immunity Requirements, Part 2: Industrial.
   3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
   4. IEC8528 part 4, Control Systems for Generator Sets.
   5. IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.
   7. NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
   8. NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.

1.05 TESTING

A. To ensure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.

B. Design Prototype Tests. Components of the emergency system, such as the engine/generator set, transfer switch, and accessories, shall not be subjected to prototype tests because the tests are potentially damaging. Rather, similar design prototypes and preproduction models shall be subject to the following tests:

   1. Maximum power (kW) and (kVA) at 0.8 lagging PF.
   2. Maximum motor starting (skVA) at 35% instantaneous voltage dip.
3. Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.6.
4. Governor speed regulation under steady-state and transient conditions.
5. Voltage regulation and generator transient response.
6. Harmonic analysis, voltage waveform deviation, and telephone influence factor.
7. Three-phase short circuit tests.
8. Alternator cooling air flow.
9. Torsional analysis to verify that the generator set is free of harmful torsional stresses.
10. Endurance testing.

C. Final Production Tests. Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
   1. Single-step load pickup
   2. Safety shutdown device testing
   3. Rated Power @ 0.8 PF
   4. Maximum power
   5. Upon request, a witness test, or a certified test record sent prior to shipment.

D. Site Tests. The manufacturer's distribution representative shall perform an installation check, startup, and building load test. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
   1. Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
   2. Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery chargers, alternator strip heaters, remote annunciators, etc.
   3. Generator set startup under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during operation, normal and emergency line-to-line voltage and frequency, and phase rotation.
   4. Automatic start by means of a simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test.
   5. On site minimum 4 hour load bank test with confirmed results of test in writing to A/E.
1.06 WARRANTY AND MAINTENANCE

A. The generator set shall include a five year comprehensive warranty to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from date of startup. Optional warranties shall be available upon request.

B. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and function tests performed on all systems.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. The generator set shall be a Kohler/Caterpillar/Cummins equipment with a 130 degree rise (Standby) alternator, sized per plans. It shall provide kW/kVA rating as shown on plans when operating at 277/480 volts, 60 Hz, and 0.8 lagging power factor. The generator set shall be capable of this Standby 130°C rating while operating in an ambient condition of less than or equal to 90° F and a maximum elevation of at least 3,500 feet above sea level.

B. Motor starting performance and voltage dip determinations shall be based on the complete generator set. The generator set shall be capable of supplying a minimum of TBD skVA as indicated on plans for starting motor loads with a maximum instantaneous voltage dip of 35%, as measured by a digital RMS transient recorder in accordance with IEEE standard 115. Motor starting performance and voltage dip determination that does not account for all components affecting total voltage dip i.e. engine, alternator, voltage regulator and governor will not be acceptable. As such, the generator set shall be prototype tested to optimize and determine performance as a generator set system.

C. Vibration isolators shall be provided between the engine-alternator and heavy-duty steel base.

2.02 ENGINE

A. The minimum X.X liter displacement engine shall deliver a minimum of XXX HP at a governed engine speed of 1800 rpm, and shall be equipped with the following:
   1. Electronic isochronous governor capable of 0.5% steady-state frequency regulation.
   2. 12-volt positive-engagement solenoid shift-starting motor.
3. 70-ampere automatic battery charging alternator with a solid-state voltage regulation.
4. Positive displacement, full-pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain.
5. Dry-type replaceable air cleaner elements for normal applications.
6. The engine shall be naturally aspirated and fueled by No. 2 Diesel
7. The engine shall have at least 8 cylinders and be liquid-cooled.

B. The generator must accept rated load in one-step.

C. The engine shall be EPA certified from the factory.

2.03 ALTERNATOR

A. The alternator shall be salient-pole, brushless, 2/3-pitch, 12 lead, self-ventilated with drip-proof construction and amortisseur rotor windings and skewed for smooth voltage waveform. The ratings shall meet the NEMA standard (MG1-32.40) temperature rise limits. The insulation shall be class H per UL1446 and the varnish shall be a fungus resistant epoxy. Temperature rise of the rotor and stator shall be limited to Standby 130°C. The PMG excitation system shall be of brushless construction controlled by a digital, 3-phase sensing, solid-state voltage regulator capable of maintaining voltage within ±2.0% at any constant load from 0% to 100% of rating. The AVR shall be capable of proper operation under severe nonlinear loads and provide individual adjustments for voltage range, stability and volts-per-hertz operations. The AVR shall be protected from the environment by conformal coating. The waveform harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.

B. The alternator shall have a single maintenance-free bearing, designed for 40,000 hour B10 life. The alternator shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

C. The generator shall be inherently capable of sustaining at least 300% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current-support devices.

2.04 CONTROLLER

A. Decision-Maker® 550 Controller (Kohler) or equal by Caterpillar or Cummins
   1. The generator set controller shall meet NFPA 110 Level 1 requirements (1996 version) and shall include an integral alarm horn as required by NFPA.
   2. The controller shall meet NFPA 99 and NEC requirements.
   3. The controller shall be UL 508 listed.

B. Applicability
   1. The controller shall be standard on a (to be determined).
2. The controller shall support 12 or 24 volt starting systems.
3. The controller's environmental specification shall be: -40°C to 70°C operating temperature range and 5-95% humidity, non-condensing.
4. The controller shall mount on the generator or remotely within 40 feet with viewable access.

C. Hardware Requirements
1. Control Panel shall include:
   a. The control shall have a run-off/reset-auto three-position selector switch.
   b. A controller-mounted, latch-type emergency stop pushbutton.
   c. Five indicating lights: System Ready - green; Not in Auto - yellow; Programming Mode - yellow, System Warning - yellow; and System Shutdown - red.
   d. Display with two lines of 20-alphanumeric characters, viewable in all light conditions.
   e. Sixteen position snap action sealed keypad for menu selection and data entry.
   f. For ease of use, an operating guide shall be printed on the controller faceplate.
   g. An audible alarm with alarm silence capability.
   h. Panel lights shall be supplied as standard.

D. Control Functional Requirements
1. Field-programmable time delay for engine start. Adjustment range 0-5 minutes in 1 second increments.
2. Field-programmable time delay engine cool-down. Adjustment range 0-10 minutes in 1 second increments.
3. Capability to start and run at user-adjustable idle speed during warm-up for a selectable time period (0-10 minutes), until engine reaches preprogrammed temperature, or as supported by ECM-equipped engine.
4. The idle function including engine cool down at idle speed.
5. Real-time clock and calendar for time stamping of events.
6. Output with adjustable timer for an ether injection starting system. Adjustment range, 0-10 seconds.
7. Output for shedding of loads if the generator set reaches a user programmable percentage of its kW rating. Load shed shall also be enabled if the generator set output frequency falls below 59 Hz.
8. Programmable cyclic cranking that allows up to six crank cycles and up to 35 seconds of crank time per crank cycle.
9. The capability to reduce controller current battery draw, for applications where no continuous battery charging is available. The controller vacuum fluorescent display should turn off automatically after the controller is inactive for 5 minutes.
10. Control logic with alternator protection for overload and short circuit matched to each individual alternator and duty cycle.
11. Control logic with RMS digital voltage regulation. A separate voltage regulator is not acceptable. The digital voltage regulator shall be applicable to single- or three-phase systems.

12. The capability to exercise the generator set by programming a running time into the controller. This feature shall also be programmable through the PC software.

13. Control function shall include output voltage adjustment.

14. Battle switch function selection to override normal fault shutdowns, except emergency stop and over-speed shutdown.

15. The control shall detect the following conditions and display on control panel:
   a. Customer programmed digital auxiliary input ON (any of the 21 inputs available)
   b. Customer programmed analog auxiliary input out of bounds (any of 7 inputs for ECM equipped engines and 5 inputs for non ECM engines)
   c. Emergency stop
   d. High coolant temperature
   e. High oil temperature
   f. Controller internal fault
   g. Locked rotor - fail to rotate
   h. Low coolant level
   i. Low oil pressure
   j. Master switch error
   k. NFPA common alarm
   l. Over-crank
   m. Over-speed with user-adjustable level, range 60-70 Hz.
   n. Over-voltage with user adjustable level, range 105% to 135%
   o. Over-frequency with user adjustable level, range 102% to 140%
   p. Under-frequency with user adjustable level, range 80% to 90%
   q. Under-voltage with user adjustable level, range 70% to 95%
   r. Coolant temperature signal loss
   s. Oil pressure gauge signal loss

16. Conditions resulting in generator warning (generator will continue to operate):
   a. Battery charger failure
   b. Customer programmed digital auxiliary input on (any of the 21 inputs available)
   c. Customer programmed analog auxiliary input on (any of the 7 inputs available on ECM engines and 5 inputs for non ECM engines)
   d. Power system supplying load
   e. Ground fault detected - detection by others
   f. High battery voltage - Level shall be user adjustable
   g. Range 29-33 volts for 24-volt systems
   h. High coolant temperature
i. Load shed
j. Loss of AC sensing
k. Under-frequency
l. Low battery voltage - level shall be user adjustable, range 20-25 volts for 24-volt systems.
m. Low coolant temperature
n. Low fuel level or pressure
o. Low oil pressure
p. NFPA common alarms
q. Over-current
r. Speed sensor fault
s. Weak battery
t. Alternator protection activated

E. Control Monitoring Requirements

1. All monitored functions must be viewable on the control panel display.

2. The following generator set functions shall be monitored:
   a. All output voltages - single phase, three phase, line to line, and line to neutral, 0.25% accuracy
   b. All single phase and three phase currents, 0.25% accuracy
   c. Output frequency, 0.25% accuracy
   d. Power factor by phase with leading/lagging indication
   e. Total instantaneous kilowatt loading and kilowatts per phase, 0.5% accuracy
   f. kVARs total and per phase, 0.5% accuracy
   g. kVA total and per phase, 0.5% accuracy
   h. kW hours
   i. A display of percent generator set duty level (actual kW loading divided by the kW rating)

3. Engine parameters listed below shall be monitored: (*available with ECM equipped engines)
   a. Coolant temperature both in English and metric units
   b. Oil pressure in English and metric units
   c. Battery voltage
   d. RPM
   e. Lube oil temperature*
   f. Lube oil level*
   g. Crankcase pressure*
   h. Coolant level*
   i. Coolant pressure*
   j. Fuel pressure
   k. Fuel temperature*
   l. Fuel rate
   m. Fuel used during the last run*
   n. Ambient temperature*

4. Operational records shall be stored in the control beginning at system startup.
   a. Run time hours
   b. Run time loaded hours
   c. Run time unloaded hours
d. Number of starts  
e. Factory test date  
f. Last run data including date, duration, and whether loaded or unloaded  
g. Run time kilowatt hours  

5. The following operational records shall be a resettable for maintenance purposes:  
a. Run time hours  
b. Run time loaded hours  
c. Run time unloaded hours  
d. Run time kilowatt hours  
e. Days of operation  
f. Number of starts  
g. Start date after reset  

6. The controller shall store the last one hundred generator set system events with date and time of the event.  

7. For maintenance and service purposes, the controller shall store and display on demand the following information:  
a. Manufacturer's model and serial number  
b. Battery voltage  
c. Generator set kilowatt rating  
d. Rated current  
e. System voltage  
f. System frequency  
g. Number of phases  

F. Inputs and Outputs  
1. Inputs  
   a. There shall be 21 dry contact inputs that can be user-configured to shut down the generator set or provide a warning.  
   b. There shall be 7 user-programmable analog inputs for ECM-equipped engines (5 for non-ECM engines) for monitoring and control.  
   c. Each analog input can accept 0-5 volt analog signals  
   d. Resolution shall be 1:10,000  
   e. Each input shall include range settings for 2 warnings and 2 shutdowns  
   f. All values shall be on the control panel display.  
   g. Shall be user-assigned.  
   h. Additional standard inputs required:  
      • Input for an external ground fault detector. Digital display shall show "ground fault" upon detection of a ground fault.  
      • Reset of system faults.  
      • Remote two-wire start  
      • Remote emergency stop  
   i. Idle mode enable.  

2. Outputs  
   a. All NFPA 110 Level 1 outputs shall be available.
b. Thirty outputs shall be available for interfacing to other equipment:
   • All outputs shall be user-configurable from a list of 25 functions and faults.
   • These outputs shall drive optional dry contacts.
  
c. A programmable user-defined common fault output with over 40 selections shall be available.

G. Communications
1. Provide an ECM (engine control module), the controller shall communicate with the ECM for control, monitoring, diagnosis, and meet SAE J1939 standards.
2. Industry standard Mod-bus communication shall be available.
3. A Mod-bus master shall able to monitor and alter parameters, and start or stop a generator.
4. The controller shall have the capability to communicate to a personal computer (IBM or compatible) running Windows 2007 or later.
5. Communications shall be available for serial, CAN, and Ethernet bus networks.
6. A variety of connections shall be available based on requirements:
   a. A single control connection to a PC.
   b. Multiple controls on an intranet network connected to a PC.
   c. A single control connection to a PC via phone line.
   d. Multiple controls to a PC via phone line.
7. Generator and transfer switch controls shall be equipped with communications modules capable of connecting to the same communication network.
8. The capability to connect up to 128 controls (any combination of generator sets and transfer switches) on a single network shall be supported.
9. Cabling shall not be limited to the controller location.
10. Network shall be self-powered.

2.05 ACCESSORIES

A. Battery Charger. A 10-ampere automatic float to equalize battery charger with the following features:
   1. 12 or 24 VDC output
   2. Voltage regulation of 1% from no to full load over 10% AC input line voltage variations
   3. Ammeter and voltmeter with 5% full-scale accuracy
   4. LED lamp for power indication
   5. Current limited during engine cranking, short circuit, and reverse polarity conditions
   6. Temperature compensated for ambient temperatures for -40°C to 60°C
   7. UL Listed

B. Battery Rack and Cables. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.
C. Critical Silencer. The engine exhaust silencer shall be temperature and rust resistant, and rated for critical applications. The silencer will reduce total engine exhaust noise by 25-35 db(A).

D. Circuit Breaker No. 1. The generator shall come with a factory installed, 80% rated line circuit breakers rated per plans that are UL listed, and shall provide life safety (LS) output to the “LS” ATS unit.

E. If a fire pump is present, provide factory installed load side lugs for direct connection of fire pump per NEC and NFPA requirements. Load side lug connections made at the factory shall be separated from field connections.

F. Circuit Breaker No 2. The generator shall come with a second, factory installed, 80% rated line circuit breaker rated per the plans that is UL listed, and shall provide optional stand-by (SB) output to the “SB” ATS. Separators shall be installed at the factory between output breakers and lugs when multiple breakers and/or lugs are required. Load side breaker connections made at the factory shall be separated from field connections.

G. Dry Contact Kits. The 10 Dry Contact Kit shall provide normally open and normally closed, gold-plated contacts in a form C configuration to activate warning devices and other customer-provided accessories allowing remote monitoring of the generator set. Typically, lamps, audible alarms, or other devices signal faults or status conditions.

H. Failure Relay.
   1. The common failure relay shall remotely signal auxiliary faults, emergency stop, high engine temperature, low oil pressure, overcrank, and overspeed via one single-pole, double-throw relay with 10 amps at 120 VAC contacts.
   2. The relay contacts shall be gold flashed to allow use of low current draw devices (100ma @ 28VDC min.).
   3. Once energized the relay shall remain latched until the system is reset by the main controller switch.

I. Flex Exhaust Tube. The exhaust piping shall be gas proof, seamless, stainless steel, flexible exhaust bellows with threaded NPT connection.

J. Rodent Guards. Generator rodent guards shall prevent intrusion and protect internal components.

K. Run Relay. The run relay shall provide a three-pole, double-throw relay with 10-amp/ 250 VAC contacts to indicate that the generator is running. The relay provides three sets of dry contacts for energizing or de-energizing customer devices while the generator is running (e.g. louvers, indicator lamps, etc.)
L. Standard Air Cleaner. The air cleaner shall provide engine air filtration which meets the engine manufacturer's specifications under typical operating conditions.

M. Block Heater. The block heater shall be thermostatically controlled and sized to maintain manufacturers recommended engine coolant temperature to meet the start-up requirements of NFPA 99 and NFPA 110, Level 1.

N. Provide Sub-base fuel tank, Double Wall, with level and leak detection. Tank shall be belly type with 24 hour full-load fuel supply. Contractor shall leave tank completely full after all testing and commissioning of the unit.

O. Remote Annunciator. Provide a NFPA 110 Compliant remote annunciator which duplicates main controller alarm and status reporting. Locate in main electrical room or as directed by owner.

2.06 SOUND ENCLOSURE

A. The enclosure shall be constructed from high strength, low alloy steel, aluminum or galvanized steel.

B. The enclosure shall be finish coated with powder baked paint for superior finish, durability and appearance. Enclosures will be finished in the manufacturer's standard color.

C. The enclosure shall allow the generator set to operate at full load in an ambient of 40°C - 45°C with no additional de-rating of the electrical output.

D. The enclosure shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker must meet the requirements of the National Electric Code.

E. Doors must be hinged with stainless steel hinges and hardware and be removable.

F. Doors shall be equipped with lockable latches. Locks must be keyed alike.

G. A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.

H. The complete exhaust system shall be internal to the enclosure.
I. All acoustical insulation shall be fixed to the mounting surface with pressure sensitive adhesive or mechanically fastened. In addition, all acoustical insulation mounted on a horizontal plane shall be mechanically fastened. The acoustical insulation shall be flame retardant.

J. The enclosure shall include an exhaust scoop to direct the cooling air in a vertical direction.

K. Sound Attenuation Level shall be a maximum dB (a) level of 68 measured at 7 m or (23FT).

PART 3 EXECUTION

3.01 TESTING

A. Provide 4 hour load bank test on site per NFPA.

END OF SECTION
SECTION 26 36 00

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install automatic transfer switch systems as indicated on drawings; 3 Pole or 4 Pole type and Ampacity as noted on drawings, 480Y277 Volt, 60Hz. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.

1.02 CODES AND STANDARDS - The automatic transfer switches and controls shall conform to the requirements of:

A. UL 1008 - Standard for Transfer Switch Equipment
B. IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
C. NFPA 70 - National Electrical Code
D. NFPA 110 - Emergency and Standby Power Systems
E. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
F. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
G. UL508 Industrial Control Equipment
H. CSA C22.2 No. 178 certification

1.03 ACCEPTABLE MANUFACTURERS

A. Automatic transfer switches shall be Kohler/Caterpillar/Cummins/ASCO or equal, OPEN – TRANSITION, 4-POLE.

1.04 SERVICE REPRESENTATION

A. The manufacturer shall maintain a national service organization of employing personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.
PART 2   PRODUCTS

2.01 MECHANICALLY HELD TRANSFER SWITCH

A. The transfer switch shall be electrically operated and mechanically held with double throw construction, and operated by a momentarily energized solenoid-driven mechanism. Main operators shall include overcurrent disconnect devices or linear motors.

B. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

C. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

D. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

E. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

F. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.

G. The 4-pole switch shall be true open transition type, and phase conductors will break prior to neutral upon transition in both directions. All four poles will be open prior to transfer/re-transfer to destination source and neutral shall make prior to phase conductors.

2.02 ENCLOSURE

A. The ATS shall be furnished in a NEMA 1 enclosure.

B. All standard door mounted switches and long life super bright type indicating LEDs described in section 3 shall be integrated into a flush-mounted, interface membrane or equivalent in the enclosure door for easy viewing & replacement. The panel shall be capable of having manual locking feature to allow the user to lockout all membrane mounted control switches to prevent unauthorized tampering. This cover shall be mounted with hinges and have a latch that may be padlocked. The membrane panel shall be suitable for mounting by others when furnished on open type units.
2.03 CONTROLLER DISPLAY AND KEYPAD

A. A four line, 20 character LCD display and dynamic 4 button keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the communications interface port. The following parameters shall only be adjustable via a password protected programming on the controller (dip switches shall not be acceptable):
   • Nominal line voltage and frequency
   • Single or three phase sensing
   • Operating parameter protection
   • Transfer operating mode configuration (Open transition, Closed transition, or Delayed transition)
   All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

2.04 VOLTAGE, FREQUENCY AND PHASE ROTATION SENSING id-2-7

A. Voltage (all phases) and frequency on both the normal and emergency sources shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dropout/Trip</th>
<th>Pickup/Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under voltage</td>
<td>75 to 98%</td>
<td>85 to 100%</td>
</tr>
<tr>
<td>Over voltage</td>
<td>105 to 135%</td>
<td>95 to 100% of trip</td>
</tr>
<tr>
<td>Under frequency</td>
<td>85 to 99%</td>
<td>95 to 99%</td>
</tr>
<tr>
<td>Over frequency</td>
<td>105 to 120%</td>
<td>101 to 105%</td>
</tr>
<tr>
<td>Voltage unbalance</td>
<td>5 to 20%</td>
<td>3% to 18%</td>
</tr>
</tbody>
</table>

B. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20°C to 70°C.

C. An adjustable dropout time for transient voltage and frequency excursions shall be provided. The time delays shall be 0.1 to 9.9 seconds for voltage and .1 to 15 seconds for frequency.

D. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via the communications interface port.

E. The controller shall be capable of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation shall be indicated on the LCD; the service required LED and the annunciation through communication protocol and dry contacts. In addition, the phase rotation sensing shall be capable of being defeated, if required.
F. The controller shall be capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition shall be considered a failed source.

G. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases (phase to phase and phase to neutral), frequency, and phase rotation.

**2.05 TIME DELAYS**

A. An adjustable time delay of 0 to 10 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.

B. A time delay shall be provided on transfer to the emergency source, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

C. A time delay shall be provided on re-transfer to normal. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

D. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

E. A time delay activated output signal shall also be provided to drive external relay(s) for selective load disconnect control. The controller shall be capable of controlling a maximum of 9 individual output time delays to step loads on after a transfer occurs. Each output may be individually programmed for their own time delay of up to 60 minutes. Each sequence shall be independently programmed for transferring from normal to emergency and transferring from emergency to normal. The controller shall also include the following built-in time delays for the following operations:
   1. 0 to 60 minute time delay on failure to acquire the acceptable electrical parameters from the emergency source.
   2. 0 to 60 minute time delay for a failure to synchronize on an in-phase operation.
   3. 60 minute time delay for the load disconnect position for delayed transition operation.

F. All time delays shall be adjustable in 1 second increments.

G. All time delays shall be adjustable by using the display and keypad or with a remote device connected to the communications interface port through a security-password system.

H. All time delays shall be adjustable by using the display and keypad or with a remote device connected to the communications interface port through a security-password system.
I. Each time delay shall be identified and a dynamic countdown shall be shown on the display.

2.06 ADDITIONAL FEATURES

A. The controller shall have 3 levels of security. Level 1 shall allow monitoring of settings and parameters only. The Level 1 shall be capable of restricted with the use of a lockable cover. Level 2 shall allow test functions to be performed and Level 3 shall allow setting of all parameters.

B. Membrane-type switches shall be provided for the test functions and be maintained until the end test function is activated. The test function shall be allowed through password security. It shall be possible to defeat the password requirement by way of a circuit board mounted dip switch setting. The test function shall be load, no load or auto test. The auto test function shall request an elapsed time for test. At the completion of this time delay the test shall be automatically ended and a retransfer sequence shall commence. All loaded tests shall be immediately ended and retransfer shall occur if the emergency source fails and the normal source is acceptable.

C. A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

D. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of two contacts, closed when the ATS is connected to the normal source and two contacts closed, when the ATS is connected to the emergency source.

E. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

F. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency sources (red), as determined by the voltage, frequency and phase rotation sensing trip and reset settings for each source.

G. A membrane switch shall be provided on the membrane panel to test all indicating lights and display when pressed.

H. Provide the ability to select “commit/no commit to transfer” to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.
I. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which closes to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or the communications interface port. A “not-in-auto” LED shall indicate anytime the controller is inhibiting transfer from occurring.

J. An in-phase monitor shall be a standard feature in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The in-phase monitor shall be specifically designed for and be the product of the ATS manufacturer. The in-phase monitor shall be capable of being enabled or disabled for the user interface. The in-phase monitor shall not be utilized as an alternative to open transition switching, shall only provide timing coordination between Normal – Open – Generator positions.

K. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to 21 different exercise routines based on a calendar mode. For each routine, the user shall be able to:
   1. Enable or disable the routine.
   2. Enable or disable transfer of the load during routine.
   3. Set the start time, time of day, day of week, week of month (1st, 2nd, 3rd, 4th, alternate or every).
   4. Set the duration of the run.
   5. At the end of the specified loaded exercise duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. All loaded exercises shall be immediately ended and retransfer shall occur if the standby source fails. The next exercise period shall be displayed on the main screen with the type of exercise, time and date. The type of exercise and the time remaining shall be display when the exercise is active. It shall be possible of ending the exercise event with a single button push.

L. Date and time - The date shall automatically adjust for leap year and the time shall have the capability of automatically adjusting for daylight saving and standard times.

M. System Status - The controller shall have a default display the following on:
   1. System status
   2. Date, time and type of the next exercise event
   3. Average voltage of the preferred and standby sources

Scrolling through the displays shall indicate the following:
   1. Line to line and line to neutral voltages for both sources
   2. Frequency of each source
   3. Load current for each phase
   4. Single or three phase operation
   5. Type of transition
   6. Preferred source
7. Commit or no commit modes of operation
8. Source/source mode (Utility/Gen; Gen/Gen; Utility/Utility)
9. In phase monitor enable/disable
10. Phase rotation
11. Date and time

N. Controllers that require multiple screens to determine system status or display “coded” system status messages, which must be explained by references in the operator's manual, are not permissible.

O. Self Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

P. Communications Interface - The controller shall be capable of interfacing, through a standard communications with a network of transfer switches and generators. It shall be able to be connected via an RS-485 serial communication (up to 4000 ft. direct connect or multi-drop configuration), an Ethernet connectivity (over standard 10baseT Ethernet networks utilizing a RJ-45 port or remotely utilizing a dial-up modem). This module shall allow for seamless integration of existing or new communication transfer devices and generators. Monitoring software shall allow for the viewing, control and setup of parameters of the genset and transfer switch network through a standard personal computer utilizing current Microsoft operating systems. Separate and specific transfer switch software interfaces shall not be acceptable.

Q. The transfer switch shall also be able to interface to 3rd party applications using Modbus RTU and Modbus TCP/IP open standard protocols utilizing Modbus register maps. Proprietary protocols shall not be acceptable.

R. The controller shall contain a USB port for downloading the controller's parameters and settings; exercise event schedules; maintenance records and event history. The file designator shall be the unique serial number of the transfer switch.

S. Data Logging - The controller shall have the ability to log data and to maintain the last 2000 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory. The controller shall be able to display up to the last 99 events. The remaining events shall be downloadable to be displayed on a computer.

1. Event Logging
   Data, date and time indication of any event.

2. Statistical Data
   Total number of transfers.*
   Total number of fail to transfers.*
   Total number of transfers due to preferred source failure.*
   Total number of minutes of operation.*
   Total number of minutes in the standby source.*
   Total number of minutes not in the preferred source*
Normal to emergency transfer time
Emergency to normal transfer time
System start date
Last maintenance date

The statistical data shall be held in two registers. One register shall contain data since start up and the second register shall contain data from the last maintenance reset.

T. External DC Power Supply - An optional provision shall be available to connect up to two external 12/24 VDC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead for extended periods of time. This module shall contain reverse battery connection indication and circuit protection.

PART 3 EXECUTION

3.01 TESTS AND CERTIFICATION

A. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

B. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, and installation and servicing in accordance with ISO 9001.

END OF SECTION
SECTION 26 43 13

TRANSIENT VOLTAGE SURGE SUPPRESSORS

PART 1  GENERAL

1.01  SUMMARY

A. This specification describes the mechanical and electrical requirements for a transient voltage surge suppressor herein known and shown on all drawings as TVSS. The TVSS shall be suitable for application in category C3 environments as described in ANSI/IEEE C62.41. The TVSS shall be parallel design and provide protection: Line to Line, Line to Neutral, Neutral to Ground. “Series” type TVSS units will be deemed unacceptable.

1.02  SUBMITTALS

A. The contractor shall submit all related TVSS specifications, electrical and mechanical drawings, maintenance manuals, and UL 1449 surge suppression ratings, as well as Independent tests performed on the TVSS that show that the TVSS being submitted is capable of controlling >104kA 8/20 surge current.

1.03  QUALITY ASSURANCE

A. Only pre-approved TVSS products shall be accepted.

B. Manufacturer Qualifications: All TVSS units shall be manufactured by a firm that has manufactured TVSS products, for at least 10 years. Firms must also regularly engage in the manufacturing of TVSS products for Categories B3 (ANSI/IEEE 62.41) and C3.

C. Codes and Standards
   1. UL compliance and Labeling: Listed per UL 1449 3rd Edition.
   3. NEC compliance: Comply with 2008 NEC as applicable to construction and Article 280 for installation.
   4. The TVSS shall be capable of surviving 2,500 sequential category B3 and C3 surges without failure. Follow IEEE test procedures in C62.45.
   5. The TVSS shall be warranted for no less than 10 years and shall include free replacement in whole or in part during that 10 years for any reason of failure.
PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliances with requirements, provide pre-approved product by the following:

1. Atlantic Scientific Corporation
2. Current Technology
3. Advanced Protection Technologies
4. Square-D
5. Eaton

2.02 TVSS EQUIPMENT

A. Service Entrance Suppressor:

1. The surge protection device shall be connected to a 50A overcurrent device installed in the service entrance electrical equipment with leads as short as possible and not to exceed 18 inches (ideally 10 inches).

2. The surge protection devices shall be Atlantic Scientific Corporation Model ZoneMaster Plus 150 Series (Part # 1810(4)XCA) or approved equal and must include the following ratings and accessories:
   a. 150kA 8/20 per phase surge suppression capability.
   b. Unit shall be of modular design consisting of bolt on modules (plug in type will be unacceptable) utilizing large block 40mm MOVs. The use of multiple 20mm MOV’s in parallel will not be acceptable.
   d. A 200,000 AIC Ultra-safe fused disconnect.
   f. UL Listed 1283 Extended Power Range Filter.
   g. Multi Mode Surge counter that monitors surge current NOT voltage. Multi Mode surge counter must be able to monitor total normal mode surges, common mode, or surge currents on each individual phase.
   h. Normally Open / Normally Closed Form C Dry Contacts.
   i. Unit shall have “High Voltage” Neutral to Ground Module with Red LED indicator.
   j. Unit shall have BOTH mechanical indicator flags and green LED indicators to show status of protection for each module.
   k. All plastics shall be UL 94-5V flame class rated.
   l. Housing shall be UL listed and CSA Certified.

3. Standard unit housings shall be non-metallic and meet NEMA 1, 2, 3, 3S, 4, 4X, 12 and 13 classifications.

4. Standard unit housings shall have a transparent front cover for complete visual inspection and monitoring the status of protection for each module, and onboard diagnostics, module configuration, and wiring configuration.
5. Standard unit warranty must be for at least 10 years and be stated in the manufacturer’s literature.

PART 3 EXECUTION

3.01 APPLICATION OF TVSS

A. General: Apply TVSS on the load side of the main disconnect at the electrical service entrance switchboard.

B. Coordinate system voltage, wiring configuration, and location as shown on project drawings.

3.02 INSTALLATION OF TVSS

A. Install the TVSS with # 8 AWG conductors from the main service panel. The conductors are to be as short and straight as practically possible and shall not exceed 18 inches in length. The TVSS shall be installed following the manufacturer's recommended practices and in compliance with all applicable codes.

END OF SECTION
SECTION 26 51 00

INTERIOR LIGHTING

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section includes interior lighting fixtures, lamps, drivers, ballasts, and accessories.

1.02 DEFINITIONS

A. Fixture: A complete lighting unit. Fixtures include lamps and parts required to distribute the light, position and protect lamps, and connect lamps to the power supply.

B. Luminaire: Fixture.

C. Average Life: The published time when 50 percent have failed and 50 percent have survived under normal conditions.

1.03 SUBMITTALS

Provide the following submittals:

A. Product data describing fixtures, lamps, and ballasts. Arrange product data for fixtures in order of fixture designation.

B. Shop drawings from manufacturers detailing nonstandard fixtures and indicating dimensions, weights, methods of field assembly, components, features, and accessories.

C. Maintenance data for products for inclusion in Operating and Maintenance Manual.

D. Provide complete set of fixture information and include in O&M Manuals.

1.04 QUALITY ASSURANCE

A. Listing and Labeling: Provide fixtures, ballasts, lamps, and emergency lighting units that are listed and labeled for their indicated use on the Project.

1. Special Listing and Labeling: Provide fixtures for use in damp or wet locations and recessed in combustible construction specifically listed and labeled for such use.

2. The term "Listed and Labeled": As defined in the 2008 National Electrical Code, Article 100.

3. Listing and Labeling Agency Qualification: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
B. Interior lighting fixtures, lamps, ballasts, and accessories and their installation shall comply with the requirements of the 2008 National Electrical Code.

C. Manufacturers Qualifications: Firms experienced in manufacturing fixtures that are similar to those indicated for this Project and that have a record of successful inservice performance.

D. Coordination of Fixtures With Ceiling: Coordinate fixture mounting hardware and trim with the ceiling system.

1.05 EXTRA MATERIALS

A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Owner.
   1. Lamps: 10 lamps for each 100 of each type and rating installed. Furnish at least 1 of each type.
   2. Ballasts: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
   3. Globes and Guards: 1 for each 20 of each type and rating installed. Furnish at least 1 of each type.

PART 2 PRODUCTS

2.01 FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs and sharp corners and edges

B. Sheet Metal Components: Steel, except as indicated. Components are formed and supported to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating and free from light leakage under operating conditions. Arrange to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in the operating position.

D. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass except as indicated.
   1. Plastic: Highly resistance to yellowing and other changes due to aging, exposure to heat and UV radiation.
   2. Lens Thickness: 0.125 inches, minimum.
2.02 LED & FLUORESCENT FIXTURES

A. Fixtures: Conform to UL 1570.

B. Ballasts: Conform to UL 935, "Fluorescent-Lamp Ballasts and LED Drivers."
   1. Certification: By Electrical Testing Laboratory (ETL).
   2. Type: Class P, high-power-factory type except as indicated otherwise.
   4. Voltage: Match connected circuits.

   1. Minimum Power Factor: 90 percent.
   2. Minimum Operating Frequency: 20,000 Hz.
   3. Harmonic Content of Ballast Current: Less than 10 percent.

D. Electromagnetic Interference Filters: Integral to the fixture assembly. Provide one filter for each ballast. Suppress electromagnetic interference as required by MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference."

2.03 LAMPS

A. Conform to ANSI Standards, C78 series applicable to each type of lamp.

2.04 FINISH

A. Steel Parts: Manufacturer's standard finish applied over corrosion-resistant primer, free of streaks, runs, holidays, stains, blisters, and defects. Remove fixtures showing evidence of corrosion during project warranty period and replace with new fixtures.

B. Other Parts: Manufacturer's standard finish.

PART 3 EXECUTION

3.01 INSTALLATION

A. Setting and Securing: Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's printed instructions and approved shop drawings.
B. Support For Recessed and Semirecessed Fixtures: Install fixtures so they are supported independently from the suspended ceiling support system. Install fixture support rods or wires at a minimum of four rods or wires per fixture located not more than 6 inches from fixture corners.

1. Fixtures Smaller Than Ceiling Grid: Install a minimum of four (4) rods or wires for each fixture and locate at corner of the ceiling grid where the fixture is located. Do not support fixtures by ceiling acoustical panels.

2. Fixtures of Sizes Less Than Ceiling Grid: Center in the acoustical panel. Support fixtures independently with at least two (2) 3/4-inch metal channels spanning and secured to the ceiling tees.

3. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corners.

C. Lamping: Lamp units according to manufacturer’s instructions. Fluorescent and LED lamp sources shall have minimum CRI of 82.

3.02 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results.

D. Tests: Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. Include the following in tests of emergency lighting equipment:

1. 1 ½ hour burn.

E. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.03 ADJUSTING AND CLEANING

A. Clean fixtures upon completion of installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.
SECTION 26 61 00

GENERAL LIGHTING PROVISIONS

PART 1  GENERAL

1.01  WORK INCLUDED

A. Fixtures
B. Controls
C. Lamps
D. Ballasts and Drivers
E. Exterior Fixtures
F. Emergency Lighting

1.02  SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 26.05.00.
B. Submit shop drawings for luminaries showing pertinent physical characteristics and performance data.
C. Submit samples of luminaries prior to final production at Engineer’s request on any proposed fixture substitution.
D. Provide a complete set of fixture information and include in O&M Manuals.

PART 2  PRODUCTS

2.01  ACCEPTABLE MANUFACTURERS

A. Provide fixtures as shown in the fixture schedule or approved equal.

2.02  FIXTURES

A. Provide electronic drivers in all LED fixtures and programmable rapid start ballasts in all fluorescent lighting fixtures with less than 10% total harmonic distortion suitable for roof/floor or roof/ceiling fire rating indicated on architectural plans. Ballasts and drivers shall be Cree, Sylvania, Philips, Universal, Advance, or General Electric. Recessed LED and fluorescent lighting fixtures drivers and ballasts shall be provided with integral thermal protection.
B. Provide rapid start lamps for all fluorescent fixtures. Lamps shall be General Electric and 3,500 °K, CRI of 80 or better, unless specified otherwise.

2.03 CONTROLS

A. Time switches shall be Tork, Intermatic, or Paragon of types and quantity shown on Drawings.

2.04 EMERGENCY EGRESS LIGHTING UNITS AND EXIT SIGNS

A. Provide fully automatic operation on power failure. Units shall have integral battery back-up for 1½ hours per NFPA. Units shall be connected un-switched to lighting circuits.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish, locate, and install fixtures as indicated on Drawings.

3.02 INSTALLATION

A. Mount fixtures as called for in schedule on Drawings. Determine type of ceiling to be installed in each space and furnish fixtures suitable for exact type, including roof/floor or ceiling/floor fire rated design. Recessed fixtures shall be supported from building structure.

B. Lighting fixtures shall be structurally supported. LED and Fluorescent fixtures mounted in the ceiling shall be attached to ceiling system as required by NEC 410-16(b). Surface mounted fixtures shall be supported from building structural system by rods or rods and clamps, or by fixture outlet box which in turn shall be supported by rods.

C. Receive, store, uncrate, and install light fixtures shown in schedule on drawings to be specified by others.

D. Adjust lighting fixtures to illuminate the intended area.

E. Wire recessed luminaries with Type THHN wire not smaller than No. 12.

F. Wire surface mounted luminaries with Type THHN wire not smaller than No. 12 from outlet boxes.

G. Locate no splice or tap within an arm or stem. Wire shall be continuous from splice in outlet box of building wiring system to lamp socket or ballast terminals.

END OF SECTION
SECTION 27 01 00

REFERENCE STANDARDS

PART 1  GENERAL

1.01 DESCRIPTION

A. Telecommunications systems shall be provided as indicated on drawings and as called for hereinafter.

1.02 REFERENCE STANDARDS


D. ANSI/NECA/BICSCI-568, Standard for Installing Commercial Building Telecommunications Cable.

E. ANSI/TIA 569-D, Telecommunications Pathways and Spaces.

F. ANSI/TIA 568.0-D, Generic Telecommunications for Customer Premises Standard Series
   568.1-D Commercial Building Cabling
   568-C.2 Copper Cabling Components
   568-C.3 Fiber Cabling Components
   568-C.4 Coax Cabling Components

G. ANSI/TIA 606-B, Addendum 1, Administration Standard for Commercial Telecommunications Infrastructure.

H. ANSI J-STD-607-B, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

I. ANSI/TIA 758-B, Customer owned Outside Plant Telecommunications Cabling Standard

J. ANSI/TIA-526, 7&14, Telecommunications Measurements of Optical Fiber Single and Multi Mode Power Loss

K. ANSI/TIA 310-D, Cabinets, Racks, Panels, and Associated Equipment.

L. FCC Part 68, Connection of Terminal Equipment to the Telephone Network.
M.  ADA of 2010 and Telecommunications Act of 1996, Physically Impaired and Accessibility.

N.  International Building Code – 2012


P.  ANSI/SCTE 77 Underground Enclosure Integrity

PART 2  PRODUCTS (NOT USED)

PART 3  EXECUTION (NOT USED)

END OF SECTION
SECTION 27 05 05
SELECTIVE DEMOLITION TELECOMMUNICATION SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Demolition and removal of selected portions of building or structure.
   2. Demolition, temporary removal, relocation, or reconfiguration of selected site elements and/or Information Technology (IT), Security or other Special Systems or infrastructure.
   3. Salvage of existing items to be reused or recycled.

B. Contractor shall include in the Bid all labor, materials, tools, plant, transportation, storage costs, equipment, insurance, temporary protection, permits, inspections, taxes and all necessary and related items required to provide complete demolition and cutover of existing telecommunication systems shown and described in the Specifications.

C. The Contractor is responsible for providing and coordinating phased activities and construction methods that minimize disruption to Terminal operations and provide complete and operational systems. Equipment and devices shall not be removed or reconfigured until removal or reconfiguration has been coordinated with owner and approval is given in writing.

D. The Contractor shall coordinate interfaces to existing systems that are being demolished in order to minimize disruption to the existing systems operations. Any systems outages shall be approved in advance and scheduled with ETSU. Minimum required notification is 30 days.

E. The Contractor shall coordinate IT data networks, CCTV, public address and any other IT infrastructure systems.

1.02 REFERENCES

A. Definitions
   1. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.
   2. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner [ready for reuse].
   3. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.
   4. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
1.03 ADMINISTRATIVE REQUIREMENTS

A. Pre-Demolition Meeting
   1. Conduct a pre-demolition meeting at Project Site with ETSU and all affected stakeholders.
      a. Inspect and discuss condition of construction to be selectively demolished.
      b. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
      c. Existing telecommunications rooms that have demolition work may involve electrical, mechanical and architectural demolition. Review and coordinate requirements of work performed by other trades.
      d. Review areas where existing construction is to remain and requires protection.
      e. Review procedures to be followed when critical systems are inadvertently interrupted. The Contractor shall be responsible for the coordination required with ETSU prior to device removal to ensure systems that must remain operational are not compromised during the demolition process.

1.04 SUBMITTALS

A. Action Submittals
   1. Comply with all ETSU submittal procedures given in other Sections.
   2. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, dust control and for noise control. Indicate proposed locations and construction of barriers.
   3. Submit a Schedule of selective demolition and cutover activities which indicates the following as a minimum:
      a. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's and tenants' on-site operations are uninterrupted.
      b. How long IT and security services will be interrupted and when systems cannot be disabled and temporary parallel service is required submit how this is proposed to be accomplished.
      c. The contractor's plan for coordination of shutoff, capping, and continuation of IT and all other utility services.
      d. Use of elevator and stairs.
      e. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
      f. Phone tree and procedures to be followed when critical systems are inadvertently interrupted (for each shift).
4. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition. Inventory shall contain Make/Model, Serial Number, Description, Identification, and Condition. ETSU will advise whether salvaged material shall be disposed of by Contractor, delivered to ETSU, or reused by the Contractor on another part of the project.

5. Pre-demolition Photographs or Video: Submit before Work begins.

6. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

B. Closeout Submittals
   1. Submit a list of items that have been removed and salvaged
   2. Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.
   3. Submit as-built documentation of all remaining IT and security systems conduit and cabling that remains

1.05 MATERIAL OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
   1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.06 FIELD/SITE CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
   1. Before selective demolition, Owner will remove the following items:
      a. ETSU Network Switches.

C. Field verify the existing conditions, device equipment locations to determine the extent of the demolition required. Notify Engineer of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
   1. Hazardous materials will be removed by Owner before start of the Work.
   2. If suspected hazardous materials are encountered, do not disturb; immediately notify Engineer. Hazardous materials will be removed by Owner under a separate contract.
E. Storage or sale of removed items or materials on-site is not permitted.

F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1.7 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties. Notify warrantor before proceeding. Existing warranties include the following:

B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL – SELECTIVE DEMOLITION

A. Demolition and construction methods shall conform to ETSU requirements, requirements of the State of Tennessee and all applicable building codes.

B. Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
   1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level. Remove all abandoned cable from origin to destination.
   2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
   3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
   4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and/or portable fire-suppression devices during flame-cutting operations. See IT Infrastructure Standards of Practice Volume 3, Chapter 1 – Safety Guidelines.
   5. Maintain adequate ventilation when using cutting torches.
   6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly.

C. Work in Historic Areas: Selective demolition may be performed only in areas of the Project that are not designated as historic. In historic spaces, areas, and rooms or on historic surfaces, the terms "demolish" or "remove" shall mean historic "removal" or "dismantling".

D. Removed and Salvaged Items:
   1. Clean salvaged items.
   2. Pack or crate items after cleaning. Identify contents of containers.
   3. Store items in a secure area until delivery to Owner.
   4. Transport items to Owner's designated storage area. Coordinate delivery of equipment with ETSU seven (7) days prior to delivery.
   5. Protect items from damage during transport and storage.

E. Removed and Reinstalled Items:
   1. Clean and repair items to functional condition adequate for intended reuse.
   2. Pack or crate items after cleaning and repairing. Identify contents of containers.
   3. Protect items from damage during transport and storage.
   4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
   5. Perform testing on reinstalled active systems and get sign-off by a ETSU approved inspector that systems are re-connected and working properly.

F. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Engineer, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.02 EXAMINATION

A. Verify that utilities have been disconnected and capped per ETSU approved procedures before starting selective demolition operations.

B. Review record documents of existing construction provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in record documents.

C. Survey existing condition of all IT related conduits and cables from origin to destination and correlate with requirements indicated to determine extent of selective demolition required.
D. Label all conduits and cables with origin, destination and what system they serve.

E. Consult with ETSU to determine whether systems can be disabled or whether a new parallel system needs to be installed.

F. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Engineer.

G. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.
   1. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.
   2. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.

H. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs or video.
   1. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.
   2. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.03 UTILITY SERVICES AND MECHANICAL / ELECTRICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
   1. Comply with requirements for existing services/systems interruptions.
   2. When temporary bypass systems are installed, test and get approval from Engineer before proceeding with demolition of existing systems.
   3. For existing equipment cabinets with active components in them, provide an air tight dust seal around the cabinet and circulate cooling air with a portable air conditioning unit or other means to ensure equipment does not overheat.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
1. Owner will arrange to shut off indicated services/systems when requested by Contractor. Coordinate the disconnection of all electrical circuits with the Electrical Contractor prior to disconnection.

2. Arrange to shut off indicated utilities with utility companies.

3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.

4. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated to be removed.
   a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
   f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

C. Refrigerant: Remove refrigerant from mechanical equipment to be selectively demolished according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.04 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
   1. Comply with requirements for access and protection.

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
   1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
   2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling.

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
   1. Strengthen or add new supports when required during progress of selective demolition.

3.05 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow demolished materials to accumulate on-site.
   2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
   3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.06 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

B. The contractor shall be required, on a daily basis, to dispose of any demolished material not required to be returned to the Owner. All materials shall be transported off of the Owner's property at the expense of the Contractor.

C. At the end of each work day or shift, the Contractor shall be required to clean-up the work area and remove all construction debris such that the site is clean and usable without hazard to workers.

END OF SECTION
SECTION 27 05 28

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish and install telecommunications outside plant (OSP) facilities as indicated on drawings and set forth hereinafter.

1.02 REFERENCE STANDARDS

A. See section 27.01.00 REFERENCE STANDARDS.


PART 2 PRODUCTS

2.01 MATERIALS

A. Inner Duct: MaxCell 3x3 (MXD3456), locatable and metallically detectable for OSP, with color ID.

B. Fiber Optic OSP Cable: Single Mode – Corning Altos OS2 XXXEU4-T4701D20(black); Multimode (50um) - Corning Altos OM3 XXXTU4-T4780D20 (black); Multimode (62.5um) Corning Altos OM1 XXXKU4-T4730D20 (black); XXX=strand count. Equivalent cables by CommScope are also approved for use.

C. Connectors and housings to be compatible with fiber chosen. For Connectors use Hubbell Proclick SC or Corning Uni-Cam SC type. SM = Hubbell FCSC9000KSM or Corning 95-200-41, blue. 50um MM = Hubbell FCS900K50M or Corning 95-050-41, black. 62.5um MM = Hubbell FCS900K62M or Corning 95-000-41, beige. For SC Bulkhead housings use Hubbell or Corning to match connectors, Hubbell FSPSCD series or Corning CCH series as applicable.

D. Copper OSP Cable: 50 Pair PE89 BSW (Buried Service Wire) Phone Cable-as manufactured by Essex or General Cable.
E. UTP Protectors for CAT3 shall be Circa 1880 series, 110 block, 5 pin modules, 4BIS-300. CAT5E shall be Linx CAT5e-75.

F. OSP Coax installation:
   1. OSP Coax shall be flooded type, CommScope PIII 500 JCASS (under 500ft), PII 750 JCASS (over 500ft).
   2. Coax .500 Series Fitting shall be Gilbert GRS-500-CH-DU-03-T
   3. Coax .750 Series Fitting shall be Gilbert GRS-750-CH-DU-03-T
   4. CANUSA Heat Shrink and Cable to Fitting transitions
   5. Coax Female to Female Adaptor shall be Gilbert G-CH-BAFF-KS-KS.

D. Handholes (HH) - Handholes shall be 36"x60"x 36D" minimum size, with open bottom (on top of 4" rack). Handhole lids shall be traffic rated (AASHTO H-20) with "COMMUNICATIONS" logo on cover of lid. Use Quazite PG style with pull slot center pins. See ETSU CIS and ITS Design and Installation Standards Policy for more information.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide two (2) 3x3 "MaxCell" innerducts in each of the 4" conduits entering building from OSP system. Where conduits over 1" not filled with MaxCell, install 3/8" nylon rope with a pull rating of 200lb or more. Conduits 1" or less, fill with polyline (Greenlee 430). Each MaxCell is to have different color ID marking and shall be locatable. The use of flexible plastic innerduct shall not be permitted.

B. The use of 90-degree bends shall be prohibited for OSP conduits. Long communications sweeps shall be utilized where conduit turns are required. Use Schedule 80 PVC, under sidewalks, driveways, etc. Use Schedule 40 PVC elsewhere. Conduit to be free of water and debris throughout. Provide caps on ends of unused conduits. For filled conduits fill ends with duct-seal after cables are installed and terminated.

C. OSP conduits shall be marked with Detectable Warning Tape, CH Hansen 16626 or equal.

D. Handholes (HH) shall be 36"x60"x 36D" minimum size, with open bottom. Seal conduits at each HH to keep moisture, insects, and rodents out of building. Conduits entering building must be sloped. All Handholes where fiber splices are made shall be 36"x60"x36D" minimum. Box lid shall be installed flush with finished grade at entire perimeter.

E. All OSP cabling shall be installed in neat and workmanlike manner. Cabling to be routed and secured around edges of HH to create additional space for future cabling.

F. Provide 50 foot maintenance loop for fiber optic lines and 25 foot for copper lines in all HH. Service loops to side of HH.
G. Label all OSP cabling as follows:
   1. "Caution Fiber Optic" adhesive marker every HH. Label to include SM and MM fiber count and "to and from".
   2. "Caution Fiber Optic" adhesive marker every 50' of exposed fiber in building (including in cable tray). Label to include SM and MM fiber count and "to and from".
   3. OSP UTP cables shall be labeled with permanent, neat penmanship in every HH with "to and from".

H. Prior to backfill, contractor shall arrange for inspection of OSP installation with ETSU ITS Department.

I. Prior to commencing with work, a pre-construction meeting will be held between the contractor's telecommunications cabling installer and appropriate representatives of the ETSU Physical Plant, ITS Department. Installation requirements shall be carefully discussed at the pre-construction meeting. Discrepancies between contract documents and pre-construction meeting shall be called to the attention of Project Engineer immediately prior to commencing with any telecommunications installation work.

J. All conduit shall be installed such that the top of the conduit is a minimum of 24" below grade.

K. Terminate all new back-bone cables within Main IT Room, 144 on lower level of building. Coordinate with ETSU ITS for cut-over and cross-connect.

L. For Century-Link fiber, coordinate their fiber install and cut-over with the new duct bank with the owner and minimize all outages of service. Any required outages must be coordinated and approved by the owner.

END OF SECTION
SECTION 27 05 29
HANGERS AND SUPPORT

PART 1  GENERAL

1.01  SCOPE OF WORK

A. Furnish and install a system of cabling supports above lay-in ceilings for network, voice, and CATV cabling as set forth hereinafter.

1.02  REFERENCE STANDARDS

A. See SECTION 27.01.00 REFERENCE STANDARDS

PART 2  PRODUCTS

2.01  MATERIALS

A. J-hooks shall be utilized above lay-in ceilings in individual rooms downstream of the cable tray for support of low-voltage cabling. J-hooks shall be as follows:
Use Panduit J-Pro Series non-metallic J-hooks for all horizontal cabling from outlet to cable tray. Steel J-hooks shall not be used.

B. Cabling support shall be located 4’ to 5’ on center throughout the entire length of network and CATV cabling runs above ceiling, once cable leaves cable tray. Provide separate sets of low-voltage cabling supports along entire length of low-voltage cabling runs above ceiling to allow separation of network cabling and CATV cabling. Network cabling shall be installed in separate J-hook support system from CATV cabling. Locate supports well clear of acoustical lay-in ceiling tiles. Supports shall be located such that tiles can be removed without interfering with support system. J-hook supports shall be secured directly to metal wall studs or masonry walls, as applicable. J-hooks shall not be attached directly to gyp-board walls. J-hooks shall be located no further apart than 5’0” on center along entire length of runs, with supports adjusted to be closer together as needed to attach to metal studs. A maximum of 8 Category 6 cables shall be installed per J-hook.

C. Provide cable tray as listed in ETSU CIS throughout corridor areas of the building for support of horizontal cabling runs originating in IDF communications rooms. XX” wide x 4” deep with trapeze type hangers 8 foot on center. XX stands for width in inches of cable trays shown on communications plans.

D. Provide all necessary supports and attachments to allow connection to structure for these supports. Provide all necessary conduits, raceways, cable trays, sleeves, etc. as necessary for the installation.
PART 3  EXECUTION

3.01  INSTALLATION

A. Entire installation shall be in accordance with manufacturer's recommendations.

B. Cable tray shall be installed per manufacturer's recommendations and shall be grounded. Cable tray shall be used for both CAT 6 and CATV cabling.

C. Provide two separate sets of low-voltage cabling supports along entire length of low-voltage cabling runs above ceiling, once leaving cable tray. One set of supports shall be of Category 6 network wiring. The second set of supports shall be for CATV wiring. Locate supports well clear of acoustical lay-in ceiling tiles. Supports shall be located such that tiles can be removed without interfering with support system.

D. Coordinate installation of low-voltage supports with other trades as required.

END OF SECTION
SECTION 27 05 43

TELECOMMUNICATIONS DUCTS AND RACEWAYS FOR OUTSIDE PLANT (OSP)

PART 1   GENERAL

1.01 DESCRIPTION

A. Furnish and install telecommunications outside plant (OSP) conduit facilities as indicated on drawings and set forth hereinafter.

1.02 REFERENCE STANDARDS

A. See section 27.01.00 REFERENCE STANDARDS.


D. ETSU Communications Infrastructure Standard (CIS) policy 500.2, September 11, 2017.


PART 2   PRODUCTS

2.01 MATERIALS

A. Inner Duct: MaxCell 3x3 (MXD3456), locatable and metallically detectable for OSP, with color ID. Two per conduit

B. Conduit & Fittings: Carlon Schedule 40 PVC. Equivalent conduits by Cantex, Allied, and JM Eagle are also approved for use.

C. PVC Primer & Cement: Oatey or Cantex for gray PVC.

D. Handholes - Handhole lids shall be traffic rated (AASHTO H-20) with "Communications" logo on cover of lid. See ETSU CIS and ITS Design and Installation Guidelines for more information.

PART 3   EXECUTION

3.01 INSTALLATION

A. Provide two (2) 3x3 "MaxCell" innerducts in each of the 4" conduits entering building from OSP system. For conduits over 1", not filled with
MaxCell, install 3/8” nylon rope with a pull rating of 200lb or more. Conduits 1” or less, fill with polyline (Greenlee 430). Each MaxCell is to have different color ID marking and shall be locatable. The use of flexible plastic innerduct shall not be permitted.

B. The use of standard short radius 90-degree bends shall be prohibited for OSP conduits. Long communications sweeps shall be utilized where conduit turns are required. Use 45-degree long sweeps at handhole locations. Use Schedule 80 PVC, under sidewalks, driveways, etc. Use Schedule 40 PVC elsewhere. Conduit to be free of water and debris throughout. Provide caps on ends.

C. OSP conduits shall be marked with Detectable Warning Tape, CH Hansen 16626 or equal.

D. Handholes (HH) shall be 36”x60”x 36D” minimum size, with open bottom (on top of 4” rack). Seal conduits at each HH to keep moisture, insects, and rodents out of building. Conduits entering building must be sloped. All Handholes where fiber splices are made shall be 36”x60”x36D” minimum. Use Quazite PG style with pull slot center pins, lid shall be labeled “COMMUNICATIONS”.

H. Prior to backfill, contractor shall arrange for inspection of OSP installation with ETSU ITS Department.

I. Prior to commencing with work, a pre-construction meeting will be held between the contractor's telecommunications cabling installer and appropriate representatives of the ETSU Physical Plant, ITS Department. Installation requirements shall be carefully discussed at the pre-construction meeting. Discrepancies between contract documents and pre-construction meeting shall be called to the attention of Project Engineer immediately prior to commencing with any telecommunications installation work.

J. All conduit shall be installed such that the top of the conduit is a minimum of 24” below grade.

END OF SECTION
SECTION 27 05 53

ADMINISTRATION / LABELING

PART 1 GENERAL

1.01 DESCRIPTION

A. Provide administration and labeling of entire communications infrastructure in accordance with ETSU ITS Department requirements and as set forth hereinafter. Administration and labeling shall include but not be limited to all work area outlets (WAO's), patch panels, 110 blocks, conduits, cable trays, backbone cables, etc.

1.02 REFERENCE STANDARDS

A. See SECTION 27.01.00 REFERENCE STANDARDS

PART 2 PRODUCTS

2.01 MATERIALS

A. Products shall be as set forth elsewhere in these specifications.

PART 3 EXECUTION

3.01 INSTALLATION

A. All WAO's, patch panels, 110 blocks, conduits, cable trays, backbone cabling, outside plant cabling, etc., shall be labeled according to ANSI/TIA/EIA Standards with specific labeling scheme of ETSU OIT Department. Labeling is also to include the following:

1. "Caution Fiber Optic" adhesive marker every 20' of exposed fiber in building (including in cable tray). Label to include SM and MM fiber count and "to and from".

END OF SECTION
SECTION 27 11 10

TELECOMMUNICATIONS SPACES

PART 1 GENERAL

1.01 DESCRIPTION

A. Telecommunications spaces shall be provided as indicated on drawings and as called for hereinafter. Telecommunications spaces shall consist of equipment rooms (ER).

1.02 REFERENCE STANDARDS

A. See section 27.01.00 for standards.

PART 2 PRODUCTS

2.01 MATERIALS

A. ER layouts shall include network racks, vertical wire management, cable trays, and associated facilities. Each ER shall include, but not be limited to, the following equipment:

1. Equipment Racks in all IT/MDF Room shall be Hubbell No. CS1976, 84" x 19" with VS86 6" Z channel vertical wire management or equivalent. Provide a Hubbell RKTGB grounding bus bar in each equipment room. Provide a Hubbell MCCPS19TS surge protected power strip for each network rack. Provide cable management components at each rack including Hubbell HC219CE3N (2 per patch panel) horizontal management, Hubbell MCCPSR4 cable management rings, and Hubbell 110RA cable management troughs. Provide Hubbell MCCS19P equipment shelves. Provide Chatsworth 10605-019 rack base insulator kit.

2. Patch Panels shall be Hubbell 1U; unloaded. Use Hubbell UDX48E1U with CMBR supports. Provide 25% extra capacity for future growth.

3. Cable Tray: In each ER room, provide 18" wide cable tray around room and to each rack. Cable tray shall be Hubbell Next Frame 18" "HL" Series or Cooper B-Line SB17U18B.

4. Backboards: All walls of each ER room shall be provided with Fire Rated, Ready Spec or U-Tec backboards.

5. All fiber, OSP and Riser shall be terminated

PART 3 EXECUTION

3.01 INSTALLATION

A. Furnish and install at each ER location a grounding conductor from grounding bus in local ER Room AC panelboard to grounding bus bar mentioned in 2.01, A, Materials. Grounding conductors shall be copper, with "THHN/THWN" insulation, with green tape marking to indicate
grounding conductor. Refer to drawings for grounding conductor sizes. Grounding and bonding shall be in accordance with BICSI TDMM current edition, Chapter 8, and NFPA 70.

B. Before any terminations and installation of equipment, the ER must be in finished stage, free of dust and debris with all walls and ceilings painted to finish coats and finished flooring installed and treated. After terminations and equipment are installed, contractor shall keep ER room door closed and locked at all times.

END OF SECTION
**SECTION 27 15 00**

**VOICE AND NETWORK HORIZONTAL CABELING SYSTEM**

**PART 1 GENERAL**

1.01 DESCRIPTION

A. Furnish and install voice and network cabling for the building as indicated on drawings and as called for hereinafter. This specification is for a voice and network cabling system. Products specified hereinafter are Hubbell, Mohawk, CommScope, or Belden cable and Hubbell connectivity including jacks, patch panels, patch cords, and faceplates shall be utilized. The Hubbell products specified hereinafter are utilized as campus standard for ETSU. Any proposed replacement products must meet or exceed the published specifications. Alternates must be verified in the bid phase with ETSU IT by furnishing proper documentation of specifications verified by an industry-recognized test laboratory (U.L., ETL, ASTM).

B. This standard also establishes performance criteria for various system configurations and their elements.

C. Cabling contractor must maintain a full time RCDD on staff as project manager for this project. Field installers of cabling installation specified herein must be a certified trained installer using ANSI TIA Standards and the current edition of the BICSI TDMM (Telecommunications Distribution Methods Manual) as a guide for installation of inside cabling and associated components. Installer must be Hubbell Certified. Provide written documentation of these qualifications as part of the submittal process.

D. Cable tray shown in drawings and specs is for UTP and coaxial cabling on the ETSU network only. All other systems including A/V, paging, alarm, proprietary networks, and other cables must utilize their own cable tray and j-hook support system.

1.02 CABELING STRUCTURE

A. The elements of a cabling system are listed below:

1. Horizontal Cabling
2. Work Area Outlets (WAO)
3. ER Rooms (See Section 27.11.10-1)

B. Horizontal Cabling

1. Horizontal cabling shall be of star topology, each work area connector shall be terminated in the telecommunications room. The maximum horizontal distance from ER to the WAO shall be 90 meters. When deductions are made for mandatory minimum slack, the cable distance is approximately 85 meters (281 feet).

2. The amount of untwisting of individual pairs to terminate shall be
less than or equal to .5 in. for Category 6.
3. Minimum bend radius shall be 4 times the cable diameter.

C. Reference Standards
1. See Section 27.01.00 REFERENCE STANDARDS

D. Administration Standard For Communications Infrastructure:
1. Purpose: The purpose of this standard is to provide a uniform administration scheme that is independent of the applications. This standard defines guidelines for contractors involved in the installation of the computer cabling system.
2. Scope: This standard specifies the administrative requirements of the communications infrastructure within a building or campus.
3. Areas to be administered are as follows:
   a. Terminations for the communications media
   b. Communications media between terminations
   c. Pathways between terminations
   d. Spaces where terminations are located
   e. Bonding and grounding
4. Pathway and Space Administration: All spaces must be labeled. Labels should be affixed at the entrance of the space.
5. Wiring System Administration: This section describes the administration of cables, termination hardware, splices and termination position. As changes are made, effected labels, records, drawings and reports shall be updated.
   a. Horizontal and backbone subsystem cables shall be labeled at each end.
      Each termination hardware or label shall be marked with an identifier.
   b. Each termination position label shall be recorded with an identifier.
   c. Each splice closure or label shall be marked with an identifier.
   d. "TMGB" shall be marked on the Telecommunications Main Grounding Busbar and the Bonding conductors from the TMGB to the TGB locations.

E. Labeling And Color Coding:
1. Labels are divided into 3 categories:
   a. Adhesive labels shall meet adhesion, defacement and legibility requirements defined in U.L. 969. Labels shall also meet exposure requirements in U.L. 969.
   b. Insert labels shall also meet U.L. 969 requirements for defacement, legibility and general exposure.
   c. Other labels include special purpose labels, such as tie-on labels.
   d. Labels shall be used instead of marking the cable.
2. Refer to ITS Guidelines, Appendix M

F. Color Coding Rules:
1. Termination labels at the two ends of the cable shall be of the
same color.
2. Cross-connectors made between termination fields are generally of two different colors.
3. The color orange is used for the demarcation point.
4. Green is for the network connections on the customer side of the demarcation point.
5. Purple is for the termination of cables originating from common equipment.
6. White is for the first level backbone media.
7. Gray is for the second level backbone.
8. Blue is for the termination of station telecommunicators media.
9. Brown is for inter-building backbone cable terminations.
10. Yellow is for termination of auxiliary circuits, alarms, security, and other miscellaneous circuits.

G. Differentiation Of Termination Fields By Performance Category
1. If cables are of different performance classes, their ends should indicate the difference. The labels shall be marked with the proper category of the cable.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Wall-Station Jacks:
   1. Network: Hubbell Speedgain, orange, HXJ6OR.

B. Wall-Station Faceplates: Wall station faceplates in office areas shall be Hubbell AFPI4EI Series with four port angled plate, color to match electrical outlets. All unused ports shall be provided with blank inserts, Hubbell SFBE10 Series. Provide blank inserts as required.

C. Equipment Racks: See Section 27.11.10.

D. ER Cable Tray: See Section 27.11.10.

E. Voice and network horizontal cabling: Cabling shall be as specified in ITS Standards Policy, Appendix A. All network cable shall have blue outer insulation. Leave 8" of slack for each termination at wall outlet location. Leave one meter (3.28') slack at the end of each conduit run. Cable slack shall not be stored in bundled loops. Cable slack shall be stored in an extended loop or in a Figure 8 configuration. Provide two data cables to each communications outlet illustrated on the drawings, unless noted otherwise.

F. Patch Cords: Provide 6' grey patch cords to the ETSU ITS department. The patch cords shall be Hubbell model number PSX6GY. Provide one cable per patch panel port.

G. Backbone Voice Cable: Provide 50 twisted pair Cat 3 UTP riser as indicated on drawings. Backbone voice cable shall be terminated on plywood with 110, 5-pair blocks. Provide 110 troughs between backbone
and horizontal 110 blocks. Use Mohawk M58522.

H. Backbone Fiber Optic Riser Cable: Single Mode – Corning MIC DX Armored Cable OS2 XXXE81-33131-DI (yellow); Multimode (50um) - Corning MIC DX Armored Cable OM3 XXXT81-33180-DI (aqua); XXX=strand count. All fiber shall be terminated in fiber hubs per ETUS ITS standards.

I. Firestopping: Hilti CP-618 putty shall be installed inside the conduits and FS One or CP-653 re-entry sleeve shall be used outside and around the conduits.

**PART 3 EXECUTION**

3.01 INTERIOR BUILDING INSTALLATION:

A. Installation of all voice and network wiring facilities shall be by Hubbell Certified personnel regularly engaged in the installation of local area network cabling.

B. All wiring shall be color coded and terminated. All cabling shall be Cat 6 terminated to T568A wiring scheme. All network cabling shall have blue outer insulation.

C. Submit shop drawings for approval.

D. Testing shall conform to ANSI/TIA-568-B.1 standard. Testing shall be accomplished using a Hubbell approved tester. Include tester calibration date. Refer to CIS for Commissioning, Warranties, and Documentation.

E. New communications infrastructure shall be tested and certified. Follow the standards of ANSI/TIA/568-C.1, 2, 3, 4 for testing criteria of permanent link. Approved testers include Fluke, Fluke DTX1800 and 4000 Series, Ideal/Lantech, and additional testers as approved in writing by Hubbell.

F. Test Results: Provide test results as set forth hereinafter. Test results shall follow the manufacturer’s warranty submittals and shall include a copy of all results (including all UTP cabling, optical fiber cabling, and coaxial cabling). Test results shall be submitted for approval to ETSU before final certification. All test results submitted to ETSU must be submitted in their original format from tester.

G. Test results shall be provided in the following Sections, Format, and Order:

   Section 1: Cover sheet clearly indicating project name/number and date of testing.
   Section 2: Summary sheet with a single table indicating all ID’s in order, total cable quantity and a pass or fail result for each.
   Section 3: Individual sheets for each individual twisted pair cable or optical fiber strand pair in order showing all applicable test results per TIA
standards.

Note: Test results shall be submitted in the format and order as specified in the ETSU Communications Infrastructure Standard. Test results submitted in any other format will be rejected.

H. All cables shall be tested for shorts, crossed, opens, grounds, splits, and transpositions. Each cable pair will be tested and documented and the test results will be supplied to the owner for review and acceptance. Each Category 6 cable will be tested for wire map, lengths, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew. Fiber optic testing will measure the end to end attenuation bidirectional at their two corresponding wavelengths, multi-mode at 850 nm and 1300 nm, single-mode at 1310 nm and 1550 nm. All fibers shall be measured for overall length. Each cable will be documented for review and acceptance by owner. The owner will evaluate the test results for “pass/fail”. Contractor shall satisfactorily repair any failed cable test such that all cables pass as required.

I. All testing shall meet or exceed manufacturer’s recommendation for 25-year warranty program.

J. Test each pair and shield of each cable for opens, shorts, grounds, and pair reversal. Correct grounded and reversed pairs. If horizontal cable contains bad conductors or shield, remove and replace cable. Cable shall have no visible defects such as twist, kinks, and dents.

K. During installation of cabling, the bend radius of cables is not to be less than the manufacturer's specific recommendation. Minimum bend radius shall be 10 times the diameter of the cable for fiber optic cable, and 4 times the diameter of the cable for copper cable. Contractor shall take and precaution not to exceed maximum tensile rating of cabling during installation.

L. Each horizontal cabling run shall include 10' of slack at telecommunications room end and 8" of slack at the outlet end. There shall also be one meter (3.28') of slack above each wall outlet. Station cables in the telecommunications rooms can be stored in a "Figure 8" configuration to maintain the proper bend radius and provide the needed slack.

M. Labeling of cables, wall outlets, 110 blocks, conduits, cable trays, patch panels, and backbone cabling shall be performed in accordance with requirements of the ETSU ITS Department.

N. Building Automation System (BAS) Connection: Cabling connecting BAS to the ETSU ITS network must follow the standards set forth in ANSI/TIA 862.

O. Contractor shall provide all required fire-stopping of rated penetrations as required by these construction documents, applicable codes, and as required in the ETSU CIS.
P. Contractor shall provide all required bonding and grounding for telecommunications systems as required by these construction documents, applicable codes, and as required in the ETSU CIS.

**PART 4 QUALITY ASSURANCE**

4.01 QUALITY ASSURANCE:

A. Any contractor or subcontractor directly performing construction of these passive cabling systems shall maintain qualifications as detailed below for the duration of the project:

1. RCDD-of-Record Requirements
   a. The contractor or subcontractor performing construction shall maintain a BICSI Registered Communications Distribution Designer (RCDD-of-Record) overseeing the scope of work. He or she shall be a current Registered Communications Distribution Designer in good standing as awarded by BICSI from time of bid through project’s substantial completion.
   b. The RCDD-of-Record shall be a permanent employee (not subcontractor or temporary employee) of the contractor or subcontractor performing construction.
   c. The RCDD-of-Record shall submit a current and valid copy of both their RCDD certificate as well as proof of employment by the contractor or subcontractor.
   d. The Designer shall coordinate all inspections with ETSU and the RCDD-of-Record. ETSU shall be notified a minimum of ten (10) business days in advance of the final inspection to give ample time to make accommodations to participate if so desired.
   e. In addition the contractor shall have a current and active Hubbell product certification as referenced later in this document.

**PART 5 - SUBMITTALS**

5.01 SUBMITTAL REQUIREMENTS

A. All submittals shall be provided to ETSU in their entirely (including re-submittals) in both printed and PDF formats.

B. Submittals are required to be provided to ETSU for all materials to be provided/installed/fabricated. All pre-construction submittals must be approved by both the designer and ETSU prior to acquisition, installation or construction.

C. The following submittals are due in the Pre-Construction Phase
   1. Product Information
a. Provide cover sheet showing project number, name, and description. Include table of contents with all product names, manufacturer, and specific product number identified.

b. Materials and their manufacturer(s) part numbers shall be clearly called out for each item using a black arrow or circle. No highlighted submittals will be accepted.

2. Provide scaled plan and elevation drawings of the proposed layout and construction of all components in all telecommunications rooms (scale to be not less than 1/4" = 1'-0") indicating locations of bus-bars, racks, ladder rack, service loops, wall mounted equipment, etc.

D. The following submittals are due at Substantial Completion

1. Record Drawings (as-built drawings)

a. Provide scaled drawings (floor plans not less than 1/16" = 1'-0") indicating actual location and size/length of TMGB, TGBs and TBB conductors and all splice points. Also to be included are all communications outlets and other points of termination including labeling and identification.

b. Provide scaled plan and elevation drawings of telecommunications rooms (not less than 1/4" = 1'-0") indicating actual locations of TMGB and TGBs.

2. Provide a letter from the contractors Project RCDD stating that the grounding system has been installed in accordance with the project documents and the referenced codes, standards, and guidelines.

END OF SECTION
SECTION 27 15 33

COAX HORIZONTAL CABLEING

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish and install a complete 1 GHz CATV wiring system as described on drawings and called for hereinafter.

B. The catalog numbers specified herein are those of the Blonder-Tongue Company and constitute the type and quality of the products to be installed.

C. The quality and type of CATV materials must be accepted by industry standards. All passive and active equipment must be two-way and pass signals up to one GHZ "passive" and 750 MHZ "active".

D. Cable tray shown in drawings and specs is for UTP and coaxial cabling on the ETSU network only. All other systems including A/V, paging, alarm, proprietary networks, and other cables must utilize their own cable tray and j-hook support system.

1.02 INSTALLER QUALIFICATIONS

A. Installation of CATV cabling system shall be done by personnel regularly engaged in installation of such facilities. Installers shall have NCTI, SCTE, and BICSI certifications. Provide documentation of these certifications as part of the submittal process. Installer shall have working knowledge of all codes/standards related to CATV wiring installation.

1.03 DISTRIBUTION LEVELS

A. Line extender outputs shall be 46/40 DBMV for single cascade, and 43/37 DBMV for two cascades. No more than two line extenders shall be provided in cascade. Tap levels shall not exceed 17 DBMV on any "F" fitting. Typical tap level shall be 12 DBMV. Output level at faceplate shall be 3 DBMV and maximum of 10 DBMV. Maximum 3 DB variation shall be allowed between adjacent channels.

1.04 REFERENCE STANDARDS

A. SECTION 27.01.00 – REFERENCE STANDARDS

B. ANSI/SCE 74 2003, Specification for braided 75 ohm Flexible Coaxial Cable.

C. FCC Part 76, Cable Television Service.

PART 2 PRODUCTS
2.01 MATERIALS

A. Splitters: In the Telecommunications Room, install splitters to take the cable TV feed and distribute it to each individual room. Splitters/combiners shall be vertical ports, capable of passing one GHZ signal with built-in grounding lug, Truespec DSVXG or equivalent. "X" represents the number of ports. Arrange splitters/combiners so that signal is evenly distributed among all ports.

B. Wall Plates: Wall plates for CATV outlets shall be flush mounted with single-gang Standard F81 through connector with 0 db isolation, Hubbell AFP14EI.

C. Coaxial Cable: Coaxial cable shall be installed from each television outlet location shown on drawings to the Telecommunications Room on a homerun basis. No series wiring for TV shall be permitted. The coaxial cable from the outlet to the Telecommunications Room shall be Belden 7915A Series RG6 cable, aluminum braid shield, flame retardant PVC jacket meeting NEC Article 820V rating, ETL listed or equivalent.

D. Coaxial Connectors: Use compression type, Belden Thomas and Betts FSNS6U.

E. Amplifier: Provide one amplifier in Telecommunications Room. Each amplifier shall be two-way broadband distribution amplifier, Blonder-Tongue Model No. BIDA-750-30 or 750-50 as directed by ITS.

F. Riser Coax installation:
   1. Riser Coax shall be RG11 Belden 9011 if under 300 feet and Comscope PIII 500 Plenum over 300ft.
   2. RG11 Fitting shall be Thomas and Betts 716SNS1P11H
   3. Coax .500 Series Fitting shall be Gilbert GRS-500-CH-DU-03-T

PART 3 EXECUTION

3.01 INSTALLATION

A. Each coaxial cable shall be tested for signal loss, length of cable, and meet the manufacturers specifications. Testing shall be in accordance with FCC Part 76 signal leakage requirements. Coaxial cable tests will involve continuity and RF leakage, 20-uV/m leakage limit (10 feet from network). Limit will yield a dipole level of -43.67 dBmV 75 ohms. Carefully coordinate tie-in of incoming line with local cable operator. Complete TV feed to each individual outlet to verify that a proper signal is being distributed. After proper documentation disconnect each room at the headend location and make each connection for proper identification.

B. Cable drops shall be bundled by use of approved plastic ties. Tape shall not be permitted to bundle cable drops.

C. Grounding will meet NEC requirements for CATV. Refer to Article 820 of
National Electrical Code for information.

D. Label each coaxial cable end with room number of outlet.

END OF SECTION
SECTION 28 03 00
FIRE ALARM SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This Section covers fire alarm systems, including initiating devices, notification appliances, controls, and supervisory devices.

B. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.

C. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the following functions:
   1. Fire alarm and detection operations
   2. Control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.
   3. One-way supervised automatic voice alarm operations.

1.02 ACCEPTABLE MANUFACTURERS

A. Manufacturers: The equipment and service described in this specification are those supplied and supported by SimplexGrinnell and represent the base bid for the equipment. Equal equipment from Notifier will be considered.

1.03 RELATED DOCUMENTS

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

B. The work covered by this section is to be coordinated with related work as specified elsewhere in the specifications. Requirements of the following sections apply:
   1. Division 26: "Basic Electrical Materials and Methods."
   2. Division 26: "Wiring Methods."
   3. Division 21: "Fire Protection"
   4. Division 23: "HVAC Systems"

C. The system and all associated operations shall be in accordance with the following:
   1. Guidelines of the following Building Code: BOCA
   2. NFPA 72, National Fire Alarm Code
   3. NFPA 70, National Electrical Code
1.04 SYSTEM DESCRIPTION

A. General: Provide a complete, non-coded, addressable microprocessor-based fire alarm system with initiating devices, notification appliances, and monitoring and control devices as indicated on the drawings and as specified herein. Connect the new fire alarm panel to the existing toké and ring fire alarm network via fiber optic cable, make any and all fiber connections necessary for a complete fire alarm network.

B. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory. System shall be capable of storing dual configuration programs with one active and one in reserve. Panel shall be capable of full system operation during a new configuration download.

C. History Logs: The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.

D. Recording of Events: Record all alarm, supervisory, and trouble events by means of system printer. The printout shall include the type of signal (alarm, supervisory, or trouble) the device identification, date and time of the occurrence. The printout differentiates alarm signals from all other printed indications.

E. Wiring/Signal Transmission:
   1. Transmission shall be hard-wired, using separate individual circuits for each zone of alarm operation as required or addressable signal transmission, dedicated to fire alarm service only.
   2. System connections for initiating (signaling) circuits and notification appliance circuits shall be Class B.
   3. Circuit Supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive indicating audible tone.

F. Remote Access:
   1. FACP shall have the capability to provide Remote Access through a Dial-Up Service Modem using the public switched telephone system of a private switched telephone system.
2. A personal computer or technician's laptop, configured with terminal emulation software shall have the ability to access the FACP for diagnostics, maintenance reporting and information gathering.

3. FACP shall have the capability to provide Remote Access through a listed Internet Interface via a standard web browser user interface.

G. Required Functions: The following are required system functions and operating features:

1. Priority of Signals: Alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second-, third-, and fourth-level priority respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first. Annunciate all events regardless of priority or order received.

2. Noninterfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent activations.

3. Transmission to Remote Central Station: Automatically route alarm, supervisory, and trouble signals to a remote central station service transmitter provided under another contract.

4. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP and the remote annunciator, indicating the location and type of device.

5. General Alarm: A system general alarm shall include:
   a. Indication of alarm condition at the FACP and annunciator(s).
   b. Identification of the device or zone that is the source of the alarm at the FACP.
   c. Operation of audible and visible notification devices throughout the building until silenced at FACP.
   d. Closing doors normally held open by magnetic door holders.
   e. Unlocking designated doors.
   f. Shutting down supply and return fans serving zone where alarm is initiated.
   g. Closing smoke dampers on system serving zone where alarm is initiated.
   h. Initiation of smoke control sequence through the building temperature control system.
   i. Notifying the local fire department.
   j. Initiation of elevator recall in accordance with ASME/ANSI A17.1, when specified detectors or sensors are activated.
6. Supervisory Operations: Upon activation of a supervisory device such as fire pump power failure, low air pressure switch, and tamper switch, the system shall operate as follows:
   a. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the graphic annunciator.
   b. Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
   c. Record the event in the FACP historical log.
   d. Transmission of supervisory signal to remote central station.
   e. Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.

7. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible alarm signals shall cease operation.

8. System Reset
   a. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."
   b. Should an alarm condition continue, the system will remain in an alarmed state.

9. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated.

10. WALKTEST: The system shall have the capacity of 8 programmable passcode protected one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:
   a. The city circuit connection and suppression release circuits shall be bypassed for the testing group.
   b. Control relay functions associated to one of the 8 testing groups shall be bypassed.
   c. The control unit shall indicate a trouble condition.
   d. The alarm activation of any initiation device in the testing group shall cause the audible notification appliances to sound a voice announcement code to identify the device or zone.
   e. The unit shall automatically reset itself after signaling is complete.
f. Any momentary opening of an initiating or notification appliance circuit wiring shall cause the audible signals to voice announce sound for 4 seconds indicating the trouble condition.

H. Analog Smoke Sensors:
   1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
   2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
   3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 sensitivity levels ranging from 0.2% to 3.7%, programmed and monitored from the FACP.
   4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements. The reports shall be viewed on a CRT Display or printed for annual recording and logging of the calibration maintenance schedule.
   5. The FACP shall automatically indicate when an individual sensor needs cleaning. The system shall provide a means to indicate that a sensor requires cleaning. When a sensor's average value reaches a predetermined value, (3) progressive levels of reporting are provided. The first level shall indicate that a sensor is close to a trouble reporting condition and will be indicated on the FACP as "ALMOST DIRTY." This condition provides a means to alert maintenance staff of a dirty sensor without creating a trouble in the system. If this indicator is ignored, a second level "DIRTY SENSOR" condition shall be indicated at the FACP and subsequently a system trouble is reported. The sensor base LED shall glow steady giving a visible indication at the sensor location. The "DIRTY SENSOR" condition shall not affect the sensitivity level required to alarm the sensor. If a "DIRTY SENSOR" is left unattended, and its average value increases to a third predetermined value, an "EXCESSIVELY DIRTY SENSOR" trouble condition shall be indicated at the control unit.
   6. The FACP shall continuously perform an automatic self-test on each sensor which will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a "SELF TEST ABNORMAL" trouble condition.
   7. Multi-Sensors shall combine photoelectric smoke sensing and heat sensing technologies. An alarm shall be determined by either smoke detection, with selectable sensitivity from 0.2 to 3.7 %/ft obscuration; or heat detection, selectable as fixed temperature or fixed with selectable rate-of-rise; or based on an analysis of the combination of smoke and heat activity.
8. Programmable bases. It shall be possible to program relay and sounder bases to operate independently of their associated sensor.

9. Magnet test activation of smoke sensors shall be distinguished by its label and history log entry as being activated by a magnet.

I. Smoke Detectors: A maintenance and testing service providing the following shall be included with the base bid:

1. Biannual sensitivity reading and logging for each smoke sensor.
2. Scheduled biannual threshold adjustments to maintain proper sensitivity for each smoke sensor.
3. Threshold adjustment to any smoke sensor that has alarmed the system without the presence of particles of combustion.
4. Scheduled biannual cleaning or replacement of each smoke detector or sensor within the system.
5. Semi-annual functional testing of each smoke detector or sensor using the manufacturer's calibrated test tool.
6. Written documentation of all testing, cleaning, replacing, threshold adjustment, and sensitivity reading for each smoke detector or sensor device within the system.
7. The initial service included in the bid price shall provide the above listed procedures for a period of five years after owner acceptance of the system.

J. Audible Alarm Notification: By voice evacuation and tone signals on loudspeakers in areas as indicated on drawings.

1. Automatic Voice Evacuation Sequence:
   a. The audio alarm signal shall consist of an alarm tone for a maximum of five seconds followed by an automatic digital voice message. At the end of the voice message, the alarm tone shall resume. This sequence shall sound continuously until the "Alarm Silence" switch is activated.
   b. All audio operations shall be activated by the system software so that any required future changes can be facilitated by authorized personnel without any component rewiring or hardware additions.

K. Speaker: Speaker notification appliances shall be listed to UL 1480.

1. The speaker shall operate on a standard 25VRMS or 70.7VRMS NAC using twisted/shielded wire.
2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.
3. The speaker shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.

L. Manual Voice Paging

1. The system shall be configured to allow voice paging. Upon activation of any speaker manual control switch, the alarm tone shall be sounded over all speakers in that group.
2. The control panel operator shall be able to make announcements via the push-to-talk paging microphone over the pre-selected speakers.

3. Facility for total building paging shall be accomplished by the means of an "All Call" switch.

M. Fire Suppression Monitoring:
1. Water flow: Activation of a water flow switch shall initiate general alarm operations.
2. Sprinkler valve tamper switch: The activation of any valve tamper switch shall activate system supervisory operations.
3. WSO: Water flow switch and sprinkler valve tamper switch shall be capable of existing on the same initiating zone. Activation of either device shall distinctly report which device is in alarm on the initiating zone.

N. Power Requirements
1. The control unit shall receive AC power via a dedicated fused disconnect circuit.
2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in a normal supervisory mode for a period of 24 hours with 15 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.
3. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.
4. The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously while incoming power is present.
5. The system batteries shall be supervised so that a low battery or depleted battery condition or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.
6. The system shall support NAC Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control
7. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary(AC) and secondary (battery) power conditions.
8. Loss of primary power shall sound a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.

1.05 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections
1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.

2. Wiring diagrams from manufacturer.

3. Shop drawings showing system details including location of FACP, all devices, circuiting and details of graphic annunciator.

4. System Power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.

5. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location or use of IDC, NAC, relay, sensor, and auxiliary control circuits.

6. Operating instructions for FACP.

7. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.

8. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.

9. Record of field tests of system.

B. Submission to Authority Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authority having jurisdiction. Include copies of shop drawings as required to depict component locations to facilitate review. Upon receipt of comments from the Authority, make resubmissions if required to make clarifications or revisions to obtain approval.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL), and shall bear the "UL" label.
1.07 MAINTENANCE SERVICE

A. Maintenance Service Contract: Provide maintenance of fire alarm systems and equipment for a period of 12 months, using factory-authorized service representatives.

B. Basic Services: Systematic, routine maintenance visits on a quarterly basis at times scheduled with the Owner. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer’s replacement parts, components, and supplies.

C. Additional Services: Perform services within the above 12-month period not classified as routine maintenance or as warranty work when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services.

PART 2 PRODUCTS

2.01 FIRE ALARM CONTROL PANEL (SIMPLEX 4100-9111) with equals by EST or Notifier.

A. General: Comply with UL 864, "Control Units for Fire-Protective Signaling Systems."

B. The following FACP hardware shall be provided:
   1. Power Limited base panel with beige cabinet and door, 120 VAC input power.
   2. 2,000 point capacity where (1) point equals (1) monitor (input) or (1) control (output).
   3. 2,000 points of Network Annunciation at FACP Display when applied as a Network Node
   4. 2000 points of annunciation where one (1) point of annunciation equals:
      a. 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module.
      b. 1 LED on panel or 1 switch on panel.
   5. From all battery charging circuits in the system provide battery voltage and ammeter readouts on the FCP LCD Display.
   6. Municipal City Circuit Connection with Disconnect switch, 24VDC Remote Station (reverse polarity), local energy, shunt master box, or a form "C" contact output.
   7. One Auxiliary electronically resetable fused 2A @24VDC Output, with programmable disconnect operation for 4-wire detector reset.
   8. One Auxiliary Relay, SPDT 2A @32VDC, programmable as a trouble relay, either as normally energized or de-energized, or as an auxiliary control.
   9. Where required provide Intelligent Remote Battery Charger for charging up to 110Ah batteries.
   10. Power Supplies with integral intelligent Notification Appliance Circuit Class B for system expansion.
11. Four (4) form "C" Auxiliary Relay Circuits (Form C contacts rated 2A @ 24VDC, resistive), operation is programmable for trouble, alarm, supervisory of other fire response functions. Relays shall be capable of switching up to ½ A @ 120VAC, inductive.

12. The FACP shall support (6) RS-232-C ports and one service port.

13. Remote Unit Interface: supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.

14. Programmable DACT for either Common Event Reporting or per Point Reporting.

15. Service Port Modem for dial in passcode access to all fire control panel information.

C. Cabinet: Lockable steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures.

D. Alphanumeric Display and System Controls: Panel shall include an 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.

E. Voice Alarm: Provide an emergency communication system, integral with the FACP, including voice alarm system components, microphones, amplifiers, and tone generators. Features include:
   1. Amplifiers comply with UL 1711, "Amplifiers for Fire Protective Signaling Systems." Amplifiers shall provide an onboard local mode temporal coded horn tone as a default backup tone. Test switches on the amplifier shall be provided to test and observe amplifier backup switchover. Each amplifier shall communicate to the host panel amplifier and NAC circuit voltage and current levels for display on the user interface.
   2. All announcements are made over dedicated, supervised communication lines. All risers shall support Class B wiring for each audio channel.
   3. Emergency voice communication audio controller module shall provide up to 32 minutes of message memory for digitally stored messages. Provide supervised connections for master microphone.

F. Fiber Optic Modem: Network communications shall be via Simplex 4100U Fiber Optic Modems. The fiber modems shall allow Full Duplex/Bi-Directional Network and Audio Communications over a single Fiber Optic Cable. Modems shall use Type ST fiber connections. Modems shall use Multi-Mode 62.5 micron fiber cable. Fiber transmission shall be via split frequency utilizing 1310nm and 1550nm. 4100-6074 Left Port Fiber Modem Assembly, and 4100-6075 Right Port Fiber Modem Assembly.
2.02 REMOTE CRTS, PC ANNUNCIATOR AND PRINTERS

A. Fire Alarm Control Unit shall be capable of operating remote CRT’s and/or printers; output shall be ASCII from an RS-232-C connection with an adjustable baud rate.

B. Fire Alarm Control Unit shall be capable of operating a PC Annunciator which provides status annunciation and limited system control using a convenient and familiar Microsoft Windows® 2000 operating system based interface. PC Annunciator shall provide the following functions:
1. Login/logout password protection with time duration selectable automatic logout
2. Displays Alarm, Supervisory, Priority 2, and Trouble conditions with numerical tallies for each
3. Displays first and last alarms
4. Different event types have separate visible indicators with a common audible indicator
5. Event logs can be searched and printed
6. View and/or print TrueAlarm status reports and service reports (printing requires an available local or network printer)
7. Alarm Silence; System Reset; and Priority 2 Reset
8. Global and individual point acknowledge
9. Set system time and date; and clear event log
10. Individual point access for control or parameter revisions

C. Each RS-232-C port shall be capable of supporting and supervising a remote Printer; the FACP shall support as many as two (2) remote displays. The Fire Alarm Control Panel shall support five (5) RS-232-C ports.

2.03 REMOTE LCD ANNUNCIATOR (SIMPLEX 4603-9101)

A. Provide Remote LCD Annunciator with the same "look and feel" as the FACP operator interface. The Remote LCD Annunciator shall use the same Primary Acknowledge, Silence, and Reset Keys, Status LEDs and LCD Display as the FACP.

B. Annunciator shall have super-twist LCD display with two lines of 40 characters each. Annunciator shall be provided with four (4) programmable control switches and associated LEDs.

C. Under normal conditions the LCD shall display a "SYSTEM IS NORMAL" message and the current time and date.

D. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The unit audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.

E. The LCD shall display the following information relative to the abnormal condition of a point in the system.
1. 40 character custom location label.
2. Type of device (e.g., smoke, pull station, workflow).
3. Point status (e.g., alarm, trouble).

F. Operator keys shall be key switch enabled to prevent unauthorized use. The key shall only be removable in the disabled position. Acknowledge, Silence and Reset operation shall be the same as the FACP.

G. General: Components include battery, charger, and an automatic transfer switch.

H. Battery: (SIMPLEX 2081-9276) Sealed lead-acid. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm indicating devices in alarm or supervisory mode for a period of 15 minutes.

2.04 ADDRESSABLE MANUAL PULL STATIONS (SIMPLEX 4099-9001)

A. Description: Addressable single-action type, red LEXAN, with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.

B. Protective Shield: Where required provide a tamperproof, clear LEXAN shield and red frame that easily fits over manual pull stations. When shield is lifted to gain access to the station, a battery powered piercing warning horn shall be activated. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.

2.05 SMOKE SENSORS

A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:
   1. Factory Nameplate: Serial number and type identification.
   2. Operating Voltage: 24 VDC, nominal.
   3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.
   4. Each sensor base (SIMPLEX 4098-9792) shall contain an LED that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the sensor base LED shall be on steady.
   5. Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
   6. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for
that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
7. The sensor’s electronics shall be immune from false alarms caused by EMI and RFI.
8. Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP. Sensor address shall be located in base to eliminate false addressing when replacing sensors.
9. Removal of the sensor head for cleaning shall not require the setting of addresses.

B. Type: Smoke sensors shall be of the photoelectric (SIMPLEX 4098-9792) or combination photoelectric / heat type (SIMPLEX 4098-9602). Where acceptable per manufacturer specifications, ionization type sensors may be used.

C. Bases: Relay output, sounder and isolator bases shall be supported alternatives to the standard base.

D. Duct Smoke Sensor: (SIMPLEX 4098-9756) Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Sensor includes relay as required for fan shutdown.
1. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct sensor shall be provided by the FACP.
2. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.
3. Duct Housing shall provide a relay control trouble indicator Yellow LED.
4. Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
5. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.
6. Duct Housing shall provide a magnetic test area and Red sensor status LED.
7. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
8. Each duct sensor shall have a Remote Test Station with an alarm LED and test switch.
9. Where indicated a NEMA 4X weatherproof duct housing enclosure shall provide for the circulation of conditioned air around the internally mounted addressable duct sensor housing to maintain the sensor housing at its rated temperature range. The housing shall be UL Listed to Standard 268A.]

2.06 HEAT SENSORS (SIMPLEX 4098-9733)
A. Thermal Sensor: Combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; 135-deg F fixed-temperature setting except as indicated.
B. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag.
C. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and] programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACP for either 15-deg F or 20-deg F per minute.
D. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

2.07 ADDRESSABLE CIRCUIT INTERFACE MODULES (SIMPLEX 4090-9001)
A. Addressable Circuit Interface Modules: Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.
B. All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

2.08 MAGNETIC DOOR HOLDERS (SIMPLEX 2088-9608)
A. Description: Units shall be listed to UL 228. Units are equipped for wall or floor mounting as indicated and are complete with matching door plate. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source, and develops a minimum of 25 lbs. holding force.
B. Material and Finish: Match door hardware.
2.09 STANDARD ALARM NOTIFICATION APPLIANCES

A. VISIBLE ONLY: (SIMPLEX 4906-9101) Strobe shall be listed to UL 1971. The V/O shall consist of a xenon flash tube and associated lens/reflectors system. The V/O enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. V/O appliances shall be provided with selectable flash intensities of 15cd, 75cd and 110cd. Provide a label inside the strobe lens to indicate the listed candela rating of the specific Visible/Only appliance.

B. SPEAKER/VISIBLE: (SIMPLEX 4906-9151) Combination Speaker/Visible (S/V) units combine the speaker and visible functions into a common housing. The S/V shall be listed to UL 1971 and UL 1480.
   1. Twisted/shielded wire is required for speaker connections on a standard 25VRMS or 70.7VRMS NAC using and UTP conductors, having a minimum of 3 twists per foot is required for addressable strobe connections.
   2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.
   3. The S/V shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.
   4. The S/V installs directly to a 4" square, 1 1/2 in. deep electrical box with 1 1/2" extension

C. Accessories: The contractor shall furnish the necessary accessories.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.

B. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:
   1. Factory trained and certified personnel.
   2. National Institute of Certification in Engineering Technologies (NICET) fire alarm level II certified personnel.
   3. Personnel licensed or certified by state or local authority.

3.02 EQUIPMENT INSTALLATION

A. Furnish and install a complete Fire Alarm System as described herein and as shown on the plans. Include sufficient control unit(s), annunciator(s), manual stations, automatic fire detectors, smoke detectors, audible and visible notification appliances, wiring, terminations, electrical boxes, and all other necessary material for a complete operating system.
B. All fire alarm panels shall be monitored and networked via the existing campus fiber optic network.

C. Equipment Removal: After acceptance of the new fire alarm system, disconnect and remove the existing fire alarm equipment and restore damaged surfaces. Package operational fire alarm and detection equipment that has been removed and deliver to the Owner. Remove from the site and legally dispose of the remainder of the existing material. Remove all associated conduit and wiring. Provide blank cover plate over all abandoned outlets recessed in walls.

D. Water-Flow and Valve Supervisory Switches: Connect for each sprinkler valve required to be supervised.

3.03 WIRING INSTALLATION

A. System Wiring: Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the Authority Having Jurisdiction (AH) and shall be installed in accordance with the appropriate articles from the current approved edition of NFPA 70: National Electric Code (NEC).

B. Contractor shall obtain from the Fire Alarm System Manufacturer written instruction regarding the appropriate wire/cable to be used for this installation. No deviation from the written instruction shall be made by the Contractor without the prior written approval of the Fire Alarm System Manufacturer.

C. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm initiating device circuits wiring and a different color code for supervisory circuits. Color-code notification appliance circuits differently from alarm-initiating circuits. Paint fire alarm system junction boxes and covers red.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

B. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
   1. Factory trained and certified.
   2. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
   3. International Municipal Signal Association (IMSA) fire alarm certified.
4. Certified by a state or local authority.
5. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.

C. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.

D. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.

E. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.

F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.

H. Final Test, Certificate of Completion, and Certificate of Occupancy:
1. Test the system as required by the Authority Having Jurisdiction in order to obtain a certificate of occupancy.

3.05 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Clean unit internally using methods and materials recommended by manufacturer.

B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

3.06 TRAINING

A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.
1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 8 hours' training.
2. Schedule training with the Owner at least seven days in advance.

END OF SECTION
SECTION 31 00 00
SITE PREPARATION

PART 1  GENERAL

1.01  DESCRIPTION

A. General:

1. Furnish all labor, materials, tools, equipment and services for all site clearing, tree protection, stripping topsoil and demolition as indicated, in accord with provisions of Contract Documents.

2. Completely coordinate with work of all other trades.

3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

1.02  QUALITY ASSURANCE

A. Perform work in accord with OSHA and EPA requirements and state and local requirements.

1.03  SUBMITTALS (See Section 01 33 23)

A. Shop Drawings: Not required.

B. Product Data: Not required.

C. Samples: Not required.

D. Project Information: Not required.

PART 2  PRODUCTS - NOT USED

PART 3  EXECUTION

3.01  PROTECTION

A. Provide barricades, coverings, and other protection necessary to prevent damage to existing improvements to remain:

1. Protect improvements on adjoining properties as well as those on Owner's property.

2. Restore any improvements damaged by this work to original condition, as acceptable to Owner or other parties or authorities having jurisdiction.
B. Protect existing trees and other vegetation to remain against damage:

1. Do not smother trees by stockpiling construction materials or excavated materials within drip line.
2. Avoid foot or vehicular traffic or parking of vehicles with drip line.
3. Provide temporary protection as required. This includes temporary fencing, barricades, warning tape or other materials or means which are needed to protect the public and the contractor’s forces.

3.02 IMPROVEMENTS ON ADJOINING PROPERTY

A. None Required.

3.03 TOPSOIL SALVAGE

A. Definitions:

1. Topsoil: Friable clay loam surface soil found in depth of not less than 4 IN (100 mm).
2. Satisfactory Topsoil: Reasonably free of subsoil, objects over 2 IN (50 mm) in diameter, weeds, and roots.

B. Strip topsoil to whatever depths encountered, in manner to prevent intermingling with underlying subsoil or objectionable material.

1. Where trees are indicated to be left standing, stop topsoil stripping sufficient distance from such trees to prevent damage to main root system.

C. Stockpile Topsoil where Directed:

1. Construct storage piles to freely drain surface water.
2. Seed or cover storage piles to prevent erosion.

D. Strip topsoil in all areas where changes of grade occur.

3.04 REMOVAL OF IMPROVEMENTS

A. Remove surfacing and pavements, including bases, concrete slabs, concrete curb and gutter, valve boxes, concrete walls, posts, poles, fences, manhole frames and covers, and other items indicated.

3.05 DISPOSAL OF WASTE MATERIALS

A. Do not burn combustible materials on site.
B. Remove all waste materials from site.
C. Do not bury organic matter on site.
D. Remove all rock, concrete, asphalt, and masonry from site.

3.06 DISPOSAL OF EXCESS TOPSOIL
A. Excess topsoil, not required for re-use on lawns, landscaped and seeded areas may be removed from the site.

3.07 REMOVAL OF DEBRIS
A. Remove all debris from the site and dispose of all removed material legally off site. Leave the site in a neat and orderly condition to the approval of the Designer. Debris receipts will be required to be turned over to the Owner.

3.08 SAFETY
A. The Contractor is to observe all Safety Laws of Local, State and Federal Government in executing this work. This specifically includes all O.S.H.A. Requirements.
B. Provide all warning signs, barricades, lights and other necessary safety devices required by Agencies mentioned in Paragraph 3.08.A.
C. Protect the occupants of the facility, the general public, and workers at all times.

3.09 CLEAN UP
A. The Contractor is to keep his operations clean at all times during execution of demolition work.
B. Streets, highways, roads, existing paved areas and sidewalks shall be cleaned of all mud, dirt, and debris daily and kept clean during construction of this project.

END OF SECTION
PART 1  GENERAL

1.01  SECTION INCLUDES

A. Rough grading and finish grading, including compaction of fill, shall be performed as a part of this contract.

B. This contract shall include trenching for utilities and footings, backfilling and compaction of trenches, and providing subbase under slabs and paving.

C. Backfill and Fill: Use soil material free of clay, rock, or gravel larger than 2: in any direction, debris, vegetable matter, waste, and frozen materials, with plasticity index less than 30.

D. Slab On Grade Subbase: Use washed, uniformly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 1-1/2” sieve and not more than 5% passing a No. 4 sieve.

E. Pavement Subbase: Use naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, natural or crushed sand, as acceptable to Designer.

F. Compaction: Provide not less than the maximum density (standard proctor) for soils compacted at optimum moisture content, for the actual density of each layer of soil material in place listed in the Soils Report recommendations in this manual.

G. Rock Excavation:
   1. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following:
      a. 24 inches (600 mm) outside of concrete forms other than at footings.
      b. 12 inches (300 mm) outside of concrete forms at footings.
      c. 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
      d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
      e. 6 inches (150 mm) beneath bottom of concrete slabs on grade. 6 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.
H. Excavation and Dewatering: It is not anticipated that ground water will be encountered in the areas of deeper undercut however dewatering will be required in trenches from stormwater.

I. Classification and Excavation: Rock is defined as solid non-soil masses other than demolition items that cannot be removed with a track mounted excavator.

END OF SECTION
SECTION 31 22 00

EXCAVATION, BACKFILLING AND COMPACTION

PART 1  GENERAL

1.01  SECTION INCLUDES

A. Excavation for building foundations.
B. Excavation for slabs-on grade, paving and landscaping.
C. Excavation for site structures.
D. Excavation for Mechanical/Electrical Work: Excavation and backfill required in conjunction with underground mechanical and electrical utilities, and buried mechanical and electrical appurtenances.
E. Backfilling of trenches.
F. Building perimeter and site structure backfilling to subgrade elevations.
G. Fill under paving.
H. Fill over excavation.
I. Consolidation and compaction.
J. Filling where required to obtain finish grade or subgrade.

1.02  REFERENCE STANDARDS


1.03  QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with contract documents and applicable requirements of governing authorities having jurisdiction.

1.04  JOB CONDITIONS

A. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that the Owner will not be responsible for interpretations or conclusions drawn therefrom by Contractor. Data is made available for convenience of Contractor.
B. Additional test borings and other exploratory operations may be made by Contractor at no cost to Owner.
C. Verify that survey benchmark and intended elevations for the Work are as indicated.

D. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

E. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

F. Do not interrupt existing utilities serving facilities occupied and used by Owner or others, during occupied hours, except when permitted in writing by Designer and then only after acceptable temporary utility services have been provided.

1. Provide minimum of 48-hour notice to Designer and receive written notice to proceed before interrupting any utility.

1.05 USE OF EXPLOSIVES

A. Explosives may not be used.

PART 2 PRODUCTS

2.01 SOIL MATERIALS

A. Fill soils shall have standard proctor (ASTM D-698) dry unit weight of greater than 90 pcf and a Plasticity Index (PI) of less than 35%. Geotechnical Engineer shall approve all fill material used on site.

B. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 1" sieve and not more than 5% passing a No. 4 sieve. Compacted crushed stone fill shall be Type A, Class A, and Grading E in accordance with section 903.05 of the Tennessee Department of Transportation Specifications.

C. Backfill and Fill Materials: Satisfactory soil materials of clay, rock or gravel not larger than 2" in any dimension, free of debris, waste, frozen materials, vegetable and other deleterious matter. Plasticity index of less than 36%.

2.02 COMMON FILL MATERIALS

A. Subsoil: Reused; or imported; excavated material free of gravel larger than 3 inch size, and debris. Plasticity index of 35% or less.

2.03 FILTER FABRIC

A. "TYPAR" 3601 or as approved equal.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify with Designer/Soils Engineer that fill materials to be reused are acceptable.

B. Verify with Designer that foundation perimeter drainage installation (if any) has been inspected.

3.02 PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Generally, compact subgrade to density requirements for subsequent backfill materials.

C. A heavily loaded, single axle dump truck utilizing a crisscross pattern should be utilized in areas that will receive structural fill to determine if any soft areas exist or sever pumping of the in place soils occur.

D. Prior to placement of aggregate base course material at building slabs or paved areas, compact subsoil to no less than 98% percent of the standard proctor maximum dry density in accordance with ANSI/ASTM D698. All fill beneath pavements and grade slabs shall be compacted to 98% percent. Moisture content of fill soils shall be maintained within +2 and -2 percentage points of the optimum moisture content determined from the standard proctor compaction test.

E. Protect bench marks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

F. Protect above and below grade utilities which are to remain.

3.03 EXCAVATION

A. Excavation is unclassified.

B. The bidder shall draw his own conclusions as to the conditions to be encountered.

C. Do not allow water to accumulate in excavations. Remove water to prevent softening of subgrade foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run off areas. Do not use trench excavations as temporary drainage
ditches.

D. Excavation for Trenches: Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide 6” to 9” clearance on both sides of pipe or conduit.

E. Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations. Beyond building perimeter, keep bottoms of trenches sufficiently below finish grade to avoid freeze ups.

Where rock is encountered, excavation shall be required to carry 1’ - 0” below required elevation and backfill with a 6” layer of crushed stone or gravel prior to installation of pipe.

F. Temporary construction excavations should be sloped or shored in accordance with Local, State and Federal Regulations including OSHA (29 CFR Part 1926) excavation and trench safety.

3.04 BACKFILL AND FILL

A. General: Place acceptable soil material in layers to required subgrade elevations, for each area.

B. Building Slab Drainage Course:

1. General: Drainage course consist of placement of a minimum of 4” of stone: Comprised of 4” of compacted crushed run stone. Crusher run stone is to be placed directly under slab.

2. Placing: Place drainage fill material on prepared subgrade in layers of uniform thickness, conforming to indicated cross section and thickness. Maintain optimum moisture content for compacting material during placement operations.

3. When a compacted drainage course is shown to be 6” thick or less, place material in a single layer. When shown to be more than 6” thick, place material in equal layers, except no single layer more than 6” or less than 2” in thickness when compacted.

3.05 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated below.

B. All compacted fill shall be constructed by spreading acceptable soil in loose layers not more than 8 inches thick. The soils used within proposed building and paved areas shall be compacted in lifts to at least 98 percent of the standard Proctor maximum dry density (ASTM D-698). At grade slabs, limit of compaction will extend...
10’ - 0” beyond edge of slab.

The moisture content of the fill soils shall be maintained within +2 and -2 percentage points of the optimum moisture content determined from the standard Proctor compaction test.

1. Lawn or Unpaved Areas: Compact top 6” of subgrade and each layer of backfill or fill material to at least 90% maximum density.

2. Walkways: Compact top 12” of subgrade and each layer of backfill or fill material to at least 98% maximum density.

3. Embankment Areas Around Buildings and Retaining Walls - 98%.

4. Paved Areas – 98% (in upper 2 feet from subgrade).

5. Paved Areas – 95% (below 2 feet from subgrade).

6. Trench Lines – per the above depending upon location/elevation.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade, or layer of soil material, to prevent free water appearing on surface during or subsequent to compaction operations.

D. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

E. Soil material that is to be removed under the building may be used if it meets the requirements of the specification for use under parking lots. It is anticipated that some soils required to be removed will not be suitable for re-use and will have to be discarded off site.

3.06 TOLERANCES

A. Top Surface of Backfilling: Under Paved Areas: Plus or minus one inch from required elevations.

B. Top Surface of General Backfilling: Plus or minus one inch from required elevations.

3.07 FIELD QUALITY CONTROL

A. Contractor will engage testing service for quality control testing and on site job observation during earthwork operations. Testing service is to be approved by the Designer prior to start of construction.

B. Tests and analysis of fill material will be performed in accordance with ANSI/ASTM D698.

C. Compaction testing will be performed in accordance with ANSI/ASTM D698.
D. If tests indicate Work does not meet specified requirements, work will be required to be removed and reworked until work meets test requirements and the requirements of the contract documents.

E. Quality Control Testing During Construction: Allow testing service to inspect and approve subgrades and fill layers before further construction work is performed.

F. Footing Sub-Grade: For each strata of soil on which footings will be placed, allow tests to verify required design bearing capacity of 2000 lbs./s.f.

G. Paved Areas and Building Slab Sub-Grade: Allow tests to verify required design bearing capacities.

H. Foundation Wall Backfill: Allow for field density tests to verify design requirements.

3.08 PROTECTION

A. Protect excavations by methods required to prevent cave in or loose soil from falling into excavation.

B. Protect bottom of excavations and soil adjacent to and beneath foundation, from freezing.

C. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris. Provide temporary drainage swales or other structures to prevent ponding of water within construction limits.

D. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

E. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

F. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other construction), add backfill material, compact, and replace disturbed construction. Restore appearance, quality, and condition of surface, finish and construction to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.09 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from Owner's Property:

1. Remove trash, debris, roots, tree stumps, mass rock, and dispose of it off
Owner's property. Contractor is responsible for material that leaves the site.

2. Remove excess soils from site. Contractor will be responsible for leveling dumped material and to make an effort to minimize run off of dumped materials. Contractor is responsible for material that leaves the site and its proper disposal.

END OF SECTION
SECTION 31 22 10

GRADING

PART 1  GENERAL

1.01  SECTION INCLUDES

A. Spread existing topsoil as required by these Specifications for proper growth of seeding, ground cover, and landscaping.

B. Excavate topsoil at areas where new walks, buildings or other miscellaneous construction is to be installed.

C. Finish grade where required.

D. Place, level, and compact topsoil.

1.02  QUALITY ASSURANCE

A. Codes and Standards: Perform grading in compliance with requirements of governing authorities having jurisdiction.

1.03  SAMPLES

A. Submit samples under provisions of Section 01 33 23.

B. Submit 10 lb. sample of imported fill to testing laboratory, in air-tight containers.

1.04  PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Section 01 33 23.

B. Accurately record location of utilities remaining, rerouted utilities, new utilities by horizontal dimensions, elevations or invert, and slope gradients.

A. Protect trees, shrubs, lawn, and other features remaining as portion of final landscaping.

B. Protect bench marks, existing structures, fences, roads, sidewalks and paving and curbs.

C. Protect above or below grade utilities which are to remain.

D. Items indicated to remain are to be repaired if damaged during construction. Restore to condition before construction.
PART 2  PRODUCTS

2.01  MATERIALS

A. Topsoil: Excavated material, graded free of roots, rocks larger than one inch subsoil, debris, and large weeds. If additional topsoil is required to complete work, Contractor shall furnish them offsite.

B. Subsoil: Excavated material, graded free of lumps larger than 6 inches; rocks larger than 3 inches and debris.

PART 3  EXECUTION

3.01  INSPECTION

A. Verify site conditions and note irregularities affecting work of this Section before beginning work.

B. Beginning work of this Section means acceptance of existing conditions.

3.02  PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Identify known below grade utilities. Stake and flag locations.

C. Identify and flag above grade utilities.

D. Maintain and protect existing utilities remaining which pass through work area.

E. Notify utility company to remove and relocate utilities.

F. Upon discovery of unknown utility or concealed conditions.
   1. If active and damaged, immediately restore to working order, discontinue affected work, notify Designer.
   2. Otherwise, discontinue affected work, notify Designer.

3.03  TOPSOIL

A. Excavate topsoil from areas to be further excavated, re-landscaped, or re-graded and stockpile on site.

B. Excavate topsoil (1-1/2' depth) from new construction areas, parking areas, any area that will require structural fill or any area which will have concrete pads or structures placed in that area. There will not be any topsoil excavation required in the building area. See drawings for further description.
C. Do not excavate wet topsoil.
D. Cover or protect topsoil from erosion.

3.04 PLACING TOPSOIL

A. Place topsoil in areas where planting is scheduled and where indicated on drawings. The majority of the site has topsoil in place.
B. Use topsoil in relatively dry state. Place during dry weather.
C. Fine grade topsoil eliminating rough or low areas. Maintain levels, profiles, and contours of subgrade.
D. Remove stone, roots, grass, weeds, debris, and foreign material while spreading.
E. Manually spread topsoil around trees, plants and building to prevent damage.
F. Lightly compact placed topsoil.
G. Remove surplus subsoil and topsoil from site. Refer to Paragraph 3.09, Section 31.22.00, Excavation, Backfilling and Compaction.
H. Leave stockpile area and site clean and raked, ready to receive landscaping.
I. Schedule of Locations:
   1. The following paragraphs identify compacted topsoil thicknesses for various locations.
   2. Seeded Grass: 6” inches.
   4. Shrub Beds: 18” inches.
   5. Flower Beds: 12” inches.

3.05 TOLERANCES

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.
B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.
C. Finish surfaces free from irregular surface changes, and as follows:
   1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10' above or below required subgrade elevations.
2. Walks: Shape surface of areas under walks to line, grade and cross section, with finish surface not more than 0.10' above or below required subgrade elevation.

3. Pavements: Shape surface of areas under pavement to line, grade and cross section, with finish surface not more than 1/2" above or below required subgrade elevation.

END OF SECTION
SECTION 31 22 81
TERMITE CONTROL

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Soil treatment for termite control, as herein specified.

1.02 QUALITY ASSURANCE
A. In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for work, including preparation of substrate and application.
B. Engage a professional pest control operator, licensed in accordance with regulations of governing authorities for application of soil treatment solution.

1.03 JOB CONDITIONS
A. Restrictions: Do not apply soil treatment solution until excavating, filling and grading operations are completed, except as otherwise required in construction operations.
B. To insure penetration, do not apply soil treatment to frozen or excessively wet soils or during inclement weather. Comply with handling and application instructions of the soil toxicant manufacturer.

1.04 SUBMITTALS
A. Product Data: Submit manufacturer's technical data and application instructions.
B. Furnish written warranty certifying that applied soil poisoning treatment will prevent infestation of subterranean termites and, that if subterranean termite activity is discovered during warranty period, Contractor will re-treat soil and repair or replace damage caused by termite infestation.

1. Provide warranty for a period of 5 years from date of treatment, signed by Applicator and Contractor.

PART 2 - PRODUCTS

2.01 SOIL TREATMENT SOLUTION
A. Provide a working solution of the following chemical element and concentration:

1. Termidor SC - Minimum Concentration .06%, 1 Gallon finished dilution/square foot around anything penetrating the slab (i.e. Utility Services, Plumbing Lines, etc.) and at 4 Gallons of dilution per 10 linear feet per foot of depth along the inside and outside perimeter of foundation walls. Treatment along inside of foundation walls at the rate of 4 Gallons finished dilution (.06%, .09%, or .125% Termidor SC) per 10
linear feet per foot of depth, or if the footing is more than 4 feet below grade.

B. Use only solutions acceptable to governing authorities. Use only soil treatment solutions which are not injurious to planting.

PART 3 - EXECUTION

3.01 PREPARATION

A. Remove foreign matter which could decrease effectiveness of treatment on areas to be treated. Loosen, rake and level soil to be treated, except previously compacted areas under slabs and foundations. Toxicants may be applied before placement of compacted fill under slabs, if recommended by toxicant manufacturer.

3.02 APPLICATION

A. Apply strictly by manufacturer's recommendations complying with all safety recommendations, environmental precautions and discretions.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. Provide labor and materials to furnish and install boulders at project locations as shown on the drawings and specified herein.

B. Related Requirements Specified Elsewhere:
   1. General Requirements: Division 1 Sections.
   2. Earthwork: Section 31 20 00.

1.02 QUALITY ASSURANCE

A. Landscape boulders and river stone shall be of a natural shape and finish. The boulders and river stone shall be provided from sources approved by the Designer.

B. Provide one (1) sample of boulder work and river stone in respective areas of the project as directed by the Designer. Area of each sample shall be no smaller than 10' by 10'. In the event sample is unacceptable prepare other sample(s) until accepted. Obtain Designer's approval in writing before beginning the work of this section.

C. Approval and Selection of Materials and Work:
   1. The selection of all materials and the execution of all operations required under the specifications and drawings is subject to the approval of the Designer. The Designer has the right to reject any and all materials and any and all work which, in the opinion of the Designer does not meet the requirements of the Contract Documents at any stage of the operations. The Contractor shall remove rejected work and or materials from job site and replace promptly.

1.03 SUBMITTALS

A. Submit to the Designer evidence of an understanding of the type of boulders required by submitting the following:
   1. Written notification stating source of satisfactory material.
   2. Photographs and/or video photography of each type of boulders proposed.
   3. Samples of river stone and pea gravel

B. Submit schedule showing scheduled dates for installation of boulders coordinated with adjacent construction.

C. Submit jobsite sample in accordance with requirements in 1.02 above.
1.04 DELIVERY AND HANDLING

A. Boulders and river stone shall be carefully handled and transported to the site and carefully placed to avoid scarring or damage to the rock material or surrounding surfaces and improvements. Scarred broken or damaged rock shall be unacceptable. Rock with exposed drill holes shall be unacceptable.

1.05 PROJECT CONDITIONS

A. Protect existing utilities, paving, structures, and other facilities from damage caused by boulder transportation and placement operations.

PART 2 PRODUCTS

2.01 LANDSCAPE BOULDERS

A. Landscape boulders shall be of rock materials indigenous to geographic area in which the project is located. Size of boulders shall not be less than specified below. Boulders larger than specified will be acceptable if they meet all other specified requirements. Color shall be gray.

B. Landscape boulders shall be provided in the approximate sizes (length, width and height) described below:

<table>
<thead>
<tr>
<th>Size</th>
<th>Boulder Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’x3’x2’</td>
<td>A</td>
</tr>
<tr>
<td>3’x5’x2’</td>
<td>B</td>
</tr>
<tr>
<td>5’x8’x3’</td>
<td>C</td>
</tr>
</tbody>
</table>

C. Rock material smaller than boulder size specified may be used as shim and blocking material.

2.02 RIVER STONE

A. River stone shall be of rock materials indigenous to geographic area in which the project is located.

B. River stones shall be rounded sandstone or quartzite which are generally the size shown on the drawings. Variation from the sizes shown on the drawings may be acceptable if the river stones meet all requirements and will accomplish the aesthetic intent.

PART 3 EXECUTION

3.01 INSTALLATION

A. Place boulders in locations and in the manner shown on the drawings. Securely stack and bury boulders below finish grade to achieve a "stepped" surface where shown on the drawings and in accordance with approved samples.

B. Provide the necessary overlap of boulders in "stepped" arrangement to minimize void spaces between boulders.
C. Install rock material smaller than specified boulder size to shim and block boulders in a stable, locked position as required. No rock smaller than the minimum size specified shall be used to form the surface of any boulder field.

3.02 ACCEPTANCE

A. All finished landscape boulders shall be stable. No rock shall be capable of being displaced by the movement or effort of three adults.

B. Upon completion of boulder work obtain Designer's approval in writing for acceptance of boulder work. Where specified work does not comply with requirements and approved samples replace and/or adjust and re-position rejected work until re-inspected by Designer and found to be acceptable. Remove rejected materials promptly from project site.

3.03 CLEANING

A. All exposed surfaces of boulders shall be cleaned as necessary to remove dirt, stains, concrete, construction debris and all other deleterious material at completion of construction operations.

B. Care shall be taken that no part of the surrounding site work be damaged by the cleaning process.

END OF SECTION
SECTION 31 25 00

TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1  GENERAL

1.01  DESCRIPTION

A. This section includes Temporary Erosion and Sediment Controls in accordance with the Tennessee General NPDES Permit (TNR10000) for storm water discharges associated with construction activity (TNCGP) as required by the State of Tennessee. Contractor is responsible for carrying out all construction activity in compliance with these requirements.

B. The construction activity will be carried out in such a manner as will prevent any discharge that would cause a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of the waters on the property or downstream of the property for fish and aquatic life, livestock watering and wildlife, recreation, irrigation, navigation, or industrial or domestic water supply.

1.02  REQUIREMENTS

A. Provide under this section all measures required by the Project Documents, Federal Clean Water Act of 1972 with 1977 Amendments and associated Tennessee State Regulations.

1.03  SPECIAL REQUIREMENTS

A. The Contractor shall identify the following to the Owner and Designer prior to commencement of soils disturbing activities.

1. Individual responsible for installation, maintenance and inspections of erosion and sediment control measures. Contractor’s assigned person shall have completed the Fundamentals of Erosion Prevention and Sediment Control course offered by the State of Tennessee.

2. Contact information for that individual including cell phone number.

3. Contractor shall be required to reimburse the Owner for any fines levied due to non-conformance or non-compliance with these requirements.

1.04  SEQUENCE OF MAJOR ACTIVITIES WHICH DISTURB SOILS

A. Safety fencing will be placed around the perimeter of the construction site.
B. Silt fencing is to be placed as shown on the Drawing L-113, detail of the fencing is shown on Drawing L-114. Silt fencing shall be installed at intervals shown in Table 1 Section “Silt Fence-SF” in the Tennessee Erosion and Sediment Control Handbook. Silt fencing and inlet protection on existing catch basins is to be installed prior to start of earth moving operations. All erosion prevention and sediment control best management practices in this project will be installed as recommended in the Tennessee Erosion and Sediment Control Handbook.

C. Sediment will be removed from sediment traps, silt fences and other sediment controls before the design capacity of the structure has been reduced by 50%. Liter, construction debris and construction chemicals exposed to storm water will be picked up prior to anticipated storm events and at the end of this area of construction. After use, silt fences will be removed or otherwise prevented from becoming a pollutant source from storm water discharges. Temporary measures may be removed at the beginning of the work day but will be replaced at the end of the work day.

D. Stabilization will be accomplished as soon as practicable after attainment of final grade and no later than seven days after attaining final grade. Where earth disturbing activity has temporarily ceased, temporary stabilization will be applied within seven days if the activity will not resume within 15 days. The dates when major grading activities temporarily of permanently cease on a portion of the site and the dates when stabilization measures are initiated will be recorded and maintained on the site by the General Contractor.

Stabilization methods are outlined in the stabilization plan and may include seed and mulch or seed and sod and erosion control blankets. Roads shall be stabilized using coarse aggregate as soon as final road grade is obtained. Note that unpacked gravel containing fines or crusher run will not be considered an acceptable stabilization practice.

E. After all earth moving activities are completed and stabilization is installed including replacement of existing concrete and the establishment of growth on seeded areas, the silt fencing and basin inlet protection will be removed.

1.05 ALTERATION OF WATERS

A. No discharges associated with industrial activities other than construction storm water is anticipated.

B. No alterations of waters anticipated.

C. Any deviation from this section must be reported, approved and permitted as required prior to commencement of construction activities.
1.06 ON SITE MATERIAL STORAGE

A. Each General Contractor and Sub-Contractor is responsible to provide litter control for trash generated by his crew. A dumpster for garbage will be located near the construction trailer and is limited to garbage and paper trash only. Paint cans, oil cans, used oil, and filters will be contained and disposed of by the General Contractor by taking them to the Washington County Hazardous Waste Disposal Center.

B. No solid materials, including building materials, shall be discharged to waters of the United States, except as authorized by a Section 404 Permit and/or Tennessee Aquatic Resource Alteration Permit.

C. Off site vehicle tracking of sediments and the generation of dust shall be minimized.

D. Concrete trucks will not be allowed to wash out on site. Wash out can only be done at the NPDES Regulated Ready Mixed Concrete Facility.

E. Controls shall be implemented to reduce pollutants from material stored on site. Controls to include water proof covering of stockpiled materials including soil, sand, etc. to prevent runoff; placing in all stored material including all steel items, bulk wiring, etc. on cribbing or pallets with a water proof covering and ventilation to prevent condensation. See specifications and manufacturers recommendations for additional storage requirements.

1.07 ADDITIONAL REQUIREMENTS

A. Interim and permanent stabilization practices includes the use of temporary seed, permanent seeding and erosion control seeding mats. Pre-construction vegetative ground cover shall not be destroyed, removed or disturbed more than 10 calendar days prior to grading or earth moving unless the area is seeded and/or mulched or other temporary cover is installed. Stabilization will be accomplished as soon as practicable after attainment of final grade and no later than seven days after attaining final grade.

B. If sediment escapes the construction site, off site accumulations of sediment that have not reached a stream must be removed at frequency sufficient to minimize offsite impacts e.g., fugitive sediment that has escaped the construction site and has collected in street must be removed so that it is not subsequently washed into storm sewers and streams by the next rain and/or so that it does not pose a safety hazard to users of public streets. Primary Contractor shall not initiate remediation/restoration of a stream without consulting the TDEC Division first.

C. Litter, construction debris, and construction chemicals exposed to storm water shall be picked up prior to anticipated storm events (e.g. forecasted by local weather reports), or otherwise prevented from becoming a pollutant source for storm water discharges (e.g. screening outfalls, daily pick up, etc.).
D. Pre-construction vegetative ground cover shall not be destroyed, removed or disturbed more than 10 calendar days prior to grading or earth moving unless the area is seeded and/or mulched or other temporary cover is installed.

1.08 IMPAIRED OR HIGH QUALITY WATERS PROVISIONS

A. If the controls are installed and maintained correctly but are found to provide an inadequate level of protection, Beeson, Lusk & Street, Inc., will make revisions to this plan and these revisions will be implemented by the General Contractor.

B. Based on the results of the inspection, any inadequate control measures or control measure in disrepair shall be replaced or modified, or repaired as necessary, by the Contractor before the next rain event, if possible, but in no case more than 7 days after the need is identified.

1.09 SPILLS AND NON-STORM WATER CONTINGENCIES

A. All fueling of equipment and vehicles on site will be conducted near the construction entrance/staging area. Any spillage will be removed immediately. Contaminated soils will be placed on heavy plastic and covered or placed into approved containers to prevent contact with storm water. All fuel tanks will be in the containment area. Oils, other vehicle fluids, paints, and solvents will be stored in the construction trailer. Any spill in excess of two gallons will be reported to the representative of the General Contractor.

B. If a release containing a hazardous substance in an amount equal to or in excess of a reporting quantity established under either 40 CFR 117 or 40 CFR 302 occurs during a 24 hour period, the General Contractor will immediately notify the permittee who shall then do the following: Notify the National Response Center (NRC) (1-800-424-8802) and the Tennessee Emergency Management Agency (TEMA) (Emergencies: 1-800-262-3300; Non-Emergency: 1-800-262-3400); as well as the Local Environmental Assistance Center. Also, Beeson, Lusk & Street, Inc., will prepare a revision of this document to identify measures to prevent the re-occurrence of such releases.

PART 2 PRODUCTS

2.01 PERMANENT AND TEMPORARY SEEDING MIXTURES

A. Utilize the following mixtures where mixtures are not specified in other areas of these specifications. See Specification Section 32 92 19 Sodding, Seeding and Groundcover.
2.02 EROSION CONTROL BLANKETS

A. The erosion control blanket shall consist of a 100% biodegradable rolled erosion control product manufactured from long lasting natural fibers mechanically attached to or woven into tow continuous 100% biodegradable netting structures. The erosion control blanket in an unvegetated state must be capable of reducing soil loss to under 0.25 inch (0.64 cm) at the bottom 10% of a 1:1, 50' feet (15.2 m) slope consisting of Loam soil for a minimum time period of 12 months. The erosion control blanket shall be North American Green C125BN or approved equal. Product performance documentation using soil loss calculations based on the USDA RUSLE method must be submitted for review. Product must be guaranteed to perform to the minimum performance standards under the specific conditions as stated above.

1. Matting:
      1. Matrix: 100% coconut fiber, minimum weight 0.50 lbs./yd2 (0.27 kg/m2).
      2. Netting: Top and bottom, woven natural fiber with 0.50-1.00 inch (1.27-2.54 cm) openings.
      3. Stitching: Biodegradable thread on 1.50 inch (3.81 cm) centers.
      4. Roll Size: 6.67 fee (2.03 m)x 108.00 feet (32.92m), 80.00 yd2 (66.89 m2).
      5. Roll Weight: + 10%: 52.22 lbs. (23.69 kg).

2. Staples:
   a. The erosion control material(s) shall be anchored with “U” shaped 11 gauge wire staples or wooden staked with a minimum top width of 1” inch (2.5 cm) and length of 6” inch (15.2 cm). Installed per manufacturer’s recommendations.

PART 3 EXECUTION

Not Used.

END OF SECTION
SECTION 31 25 10

TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1  GENERAL

1.01  DESCRIPTION

A. This section includes Temporary Erosion and Sediment Controls in accordance with the Tennessee General NPDES Permit (TNR10000) for storm water discharges associated with construction activity (TNCGP) as required by the State of Tennessee. Contractor is responsible for carrying out all construction activity in compliance with these requirements.

B. The construction activity will be carried out in such a manner as will prevent any discharge that would cause a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of the waters on the property or downstream of the property for fish and aquatic life, livestock watering and wildlife, recreation, irrigation, navigation, or industrial or domestic water supply.

1.02  REQUIREMENTS

A. Provide under this section all measures required by the Project Documents, Federal Clean Water Act of 1972 with 1977 Amendments and associated Tennessee State Regulations.

1.03  SPECIAL REQUIREMENTS

A. The Contractor shall identify the following to the Owner and Designer prior to commencement of soils disturbing activities.

   1. Individual responsible for installation, maintenance and inspections of erosion and sediment control measures. Contractor’s assigned person shall have completed the Fundamentals of Erosion Prevention and Sediment Control course offered by the State of Tennessee.

   2. Contact information for that individual including cell phone number.

   3. Contractor shall be required to reimburse the Owner for any fines levied due to non-conformance or non-compliance with these requirements.

1.04  SEQUENCE OF MAJOR ACTIVITIES WHICH DISTURB SOILS

A. Safety fencing will be placed around the perimeter of the construction site.
B. Silt fencing is to be placed as shown on the Drawing L-113, detail of the fencing is shown on Drawing L-114. Silt fencing shall be installed at intervals shown in Table 1 Section “Silt Fence-SF” in the Tennessee Erosion and Sediment Control Handbook. Silt fencing and inlet protection on existing catch basins is to be installed prior to start of earth moving operations. All erosion prevention and sediment control best management practices in this project will be installed as recommended in the Tennessee Erosion and Sediment Control Handbook.

C. Sediment will be removed from sediment traps, silt fences and other sediment controls before the design capacity of the structure has been reduced by 50%. Liter, construction debris and construction chemicals exposed to storm water will be picked up prior to anticipated storm events and at the end of this area of construction. After use, silt fences will be removed or otherwise prevented from becoming a pollutant source from storm water discharges. Temporary measures may be removed at the beginning of the work day but will be replaced at the end of the work day.

D. Stabilization will be accomplished as soon as practicable after attainment of final grade and no later than seven days after attaining final grade. Where earth disturbing activity has temporarily ceased, temporary stabilization will be applied within seven days if the activity will not resume within 15 days. The dates when major grading activities temporarily of permanently cease on a portion of the site and the dates when stabilization measures are initiated will be recorded and maintained on the site by the General Contractor.

Stabilization methods are outlined in the stabilization plan and may include seed and mulch or seed and sod and erosion control blankets. Roads shall be stabilized using coarse aggregate as soon as final road grade is obtained. Note that unpacked gravel containing fines or crusher run will not be considered an acceptable stabilization practice.

E. After all earth moving activities are completed and stabilization is installed including replacement of existing concrete and the establishment of growth on seeded areas, the silt fencing and basin inlet protection will be removed.

1.05 ALTERATION OF WATERS

A. No discharges associated with industrial activities other than construction storm water is anticipated.

B. No alterations of waters anticipated.

C. Any deviation from this section must be reported, approved and permitted as required prior to commencement of construction activities.
1.06 ON SITE MATERIAL STORAGE

A. Each General Contractor and Sub-Contractor is responsible to provide litter control for trash generated by his crew. A dumpster for garbage will be located near the construction trailer and is limited to garbage and paper trash only. Paint cans, oil cans, used oil, and filters will be contained and disposed of by the General Contractor by taking them to the Washington County Hazardous Waste Disposal Center.

B. No solid materials, including building materials, shall be discharged to waters of the United States, except as authorized by a Section 404 Permit and/or Tennessee Aquatic Resource Alteration Permit.

C. Off site vehicle tracking of sediments and the generation of dust shall be minimized.

D. Concrete trucks will not be allowed to wash out on site. Wash out can only be done at the NPDES Regulated Ready Mixed Concrete Facility.

E. Controls shall be implemented to reduce pollutants from material stored on site. Controls to include water proof covering of stockpiled materials including soil, sand, etc. to prevent runoff; placing in all stored material including all steel items, bulk wiring, etc. on cribbing or pallets with a water proof covering and ventilation to prevent condensation. See specifications and manufacturers recommendations for additional storage requirements.

1.07 ADDITIONAL REQUIREMENTS

A. Interim and permanent stabilization practices includes the use of temporary seed, permanent seeding and erosion control seeding mats. Pre-construction vegetative ground cover shall not be destroyed, removed or disturbed more than 10 calendar days prior to grading or earth moving unless the area is seeded and/or mulched or other temporary cover is installed. Stabilization will be accomplished as soon as practicable after attainment of final grade and no later than seven days after attaining final grade.

B. If sediment escapes the construction site, off site accumulations of sediment that have not reached a stream must be removed at frequency sufficient to minimize offsite impacts e.g., fugitive sediment that has escaped the construction site and has collected in street must be removed so that it is not subsequently washed into storm sewers and streams by the next rain and/or so that it does not pose a safety hazard to users of public streets. Primary Contractor shall not initiate remediation/restoration of a stream without consulting the TDEC Division first.

C. Litter, construction debris, and construction chemicals exposed to storm water shall be picked up prior to anticipated storm events (e.g. forecasted by local
weather reports), or otherwise prevented from becoming a pollutant source for storm water discharges (e.g. screening outfalls, daily pick up, etc.).

D. Pre-construction vegetative ground cover shall not be destroyed, removed or disturbed more than 10 calendar days prior to grading or earth moving unless the area is seeded and/or mulched or other temporary cover is installed.

1.08 IMPAIRED OR HIGH QUALITY WATERS PROVISIONS

A. If the controls are installed and maintained correctly but are found to provide an inadequate level of protection, Beeson, Lusk & Street, Inc., will make revisions to this plan and these revisions will be implemented by the General Contractor.

B. Based on the results of the inspection, any inadequate control measures or control measure in disrepair shall be replaced or modified, or repaired as necessary, by the Contractor before the next rain event, if possible, but in no case more than 7 days after the need is identified.

1.09 SPILLS AND NON-STORM WATER CONTINGENCIES

A. All fueling of equipment and vehicles on site will be conducted near the construction entrance/staging area. Any spillage will be removed immediately. Contaminated soils will be placed on heavy plastic and covered or placed into approved containers to prevent contact with storm water. All fuel tanks will be in the containment area. Oils, other vehicle fluids, paints, and solvents will be stored in the construction trailer. Any spill in excess of two gallons will be reported to the representative of the General Contractor.

B. If a release containing a hazardous substance in an amount equal to or in excess of a reporting quantity established under either 40 CFR 117 or 40 CFR 302 occurs during a 24 hour period, the General Contractor will immediately notify the permittee who shall then do the following: Notify the National Response Center (NRC) (1-800-424-8802) and the Tennessee Emergency Management Agency (TEMA) (Emergencies: 1-800-262-3300; Non-Emergency: 1-800-262-3400); as well as the Local Environmental Assistance Center. Also, Beeson, Lusk & Street, Inc., will prepare a revision of this document to identify measures to prevent the re-occurrence of such releases.

PART 2 PRODUCTS

2.01 PERMANENT AND TEMPORARY SEEDING MIXTURES

A. Utilize the following mixtures where mixtures are not specified in other areas of these specifications. See Specification Section 32 92 19 Sodding, Seeding and Groundcover.
2.02 EROSION CONTROL BLANKETS

A. The erosion control blanket shall consist of a 100% biodegradable rolled erosion control product manufactured from long lasting natural fibers mechanically attached to or woven into tow continuous 100% biodegradable netting structures. The erosion control blanket in an unvegetated state must be capable of reducing soil loss to under 0.25 inch (0.64 cm) at the bottom 10% of a 1:1, 50' feet (15.2 m) slope consisting of Loam soil for a minimum time period of 12 months. The erosion control blanket shall be North American Green C125BN or approved equal. Product performance documentation using soil loss calculations based on the USDA RUSLE method must be submitted for review. Product must be guaranteed to perform to the minimum performance standards under the specific conditions as stated above.

1. Matting:
      1. Matrix: 100% coconut fiber, minimum weight 0.50 lbs./yd2 (0.27 kg/m2).
      2. Netting: Top and bottom, woven natural fiber with 0.50-1.00 inch (1.27-2.54 cm) openings.
      3. Stitching: Biodegradable thread on 1.50 inch (3.81 cm) centers.
      4. Roll Size: 6.67 fee (2.03 m)x 108.00 feet (32.92m), 80.00 yd2 (66.89 m2).
      5. Roll Weight: ± 10%: 52.22 lbs. (23.69 kg).

2. Staples:
   a. The erosion control material(s) shall be anchored with “U” shaped 11 gauge wire staples or wooden staked with a minimum top width of 1" inch (2.5 cm) and length of 6" inch (15.2 cm). Installed per manufacturer’s recommendations.

PART 3 EXECUTION

Not Used.
END OF SECTION
SECTION 31 62 23

DRILLED STEEL MINIPILES (MICROPILES)

PART 1  GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SCOPE

A. This work shall consist of minipiles and caps, designed, furnished, installed and tested in accordance with these specifications and as shown on the contract drawings.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design the minipile foundation system.

B. The design professional selected by the contractor shall be approved by the Architect and Structural Engineer of Record. The design professional shall select the minipile type and the installation method, and determine the length and diameter. The contractor shall be responsible for installing in accordance with the testing subsection of this specification. Contractor's proposal for said work shall explain in detail the materials, methods, and design assumptions to be employed.

1.04 SUBMITTALS

A. See Division 01 for submittal procedures.

B. The contractor's design professional engineer shall prepare and submit to the engineer of record for review and approval, working drawings and design submission describing the pile system or systems intended for use including but not limited to piles, pile caps, and pile cap tie beams. All drawings and calculations shall be prepared under the supervision of a registered professional engineer registered in the state of Tennessee and familiar with auger micropile design and bear his seal. The working drawings and design submission shall be submitted 30 calendar days prior to the commencement of the minipile work. The working drawing and design submission shall include the following:
   1. A drawing showing the location and orientation of each minipile.
   2. A minipile schedule giving:
      a. Minipile number;
      b. Minipile design load; and
      c. Type and size of minipile.
C. The contractor shall submit to the engineer, for review and approval or rejection, mill certification for the steel piling components.

D. The contractor shall submit to the engineer, for review and approval or rejection, calibration data for each test jack, pressure gauge and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory and tests shall have been performed within 60 calendar days of the date submitted.

E. The engineer shall approve or reject the calibration data within five working days after receipt of the data. Testing cannot commence until the engineer has approved the jack, pressure gauge and master pressure gauge calibration.

F. The contractor shall submit to the engineer within 30 calendar days after completion of the minipile work a report containing:
   1. As-built drawings showing the location of the minipiles and pile lengths.
   2. Steel manufacturer’s mill test reports for the steel pile components incorporated in the installation.
   3. Detailed drilling records including depth to rock quality.
   4. Grouting records indicating the cement type and quantity injected.
   5. Minipile test results and graphs.

1.05 QUALIFICATIONS

A. The contractor performing the work described in the specification shall have installed minipiles for a minimum of five years. At the time of bid, the contractor shall submit a list containing at least five projects on which the contractor has installed minipiles. A brief description of each project and a reference shall be included for each project listed. As a minimum, the reference shall include an individual’s name and current phone number.

B. The contractor shall assign an engineer registered in Tennessee to supervise the work, with at least three years of experience in the design and construction of minipiles. The use of consultants or manufacturers’ representatives does not satisfy the requirements of this section. Drill operators and on-site supervisors shall have a minimum of one year experience installing minipiles with the contractor’s organization.

C. Work shall not be started on any piling nor materials ordered until approval of the contractor’s qualification are given. The engineer may suspend the minipile work if the contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the contractor shall be liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of work will be allowed.

D. All work covered by these specifications shall be diligently performed and the scheduled completion dates shall be met or bettered by the contractor.

E. Contractor shall submit with the bid, a detailed manpower and equipment usage schedule showing buildup requirements for maintaining schedule. After review by owner, the contractor shall comply with the schedule and execution of the work. In the event, for various reasons, the contractor fails to meet the detailed schedule, the owner
has the right to require the contractor to resort to other means to return the work to the previously agreed schedule.

F. Contractor shall submit a detailed narrative within his proposal describing the construction method to be employed, and encompassing all aspects, peripheral or otherwise, of the contractor’s site operation.

G. The owner and/or architect reserves the right to reject any or all bids on the basis of price or in the belief that the narrative content does not reveal that the contractor has given due thought to the construction process.

1.06 REGULATORY REQUIREMENTS

A. Conform to applicable code for seismic requirements for piling.

1.07 PRE-INSTALLATION MEETING

A. Convene one week prior to commencing work of this section.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement shall be Type I, II, or III conforming to ACI 150 shall be used for grout. In some applications where voids exist, sand may be added to the grout.

B. Admixtures which control bleed, improve flowability, reduce water content and retard set may be used in the grout, subject to the approval of the engineer. Admixtures, if used, shall be compatible with the manufacturer’s recommendation.

C. Water for mixing grout shall be potable.

D. Certification will be required for the steel components used in the piling.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling: Unless otherwise directed, core drilling, rotary drilling, percussion drilling, auger drilling, driven casing or other acceptable means can be used. The minipile can be installed in the drill hole after drilling or it can be advanced by the drill.

B. Grouting: The contractor shall use a neat cement grout or a sand-cement grout with a minimum 28-day unconfined compressive strength of 5,000 psi. The cement shall not contain lumps or other indications of hydration. Admixtures, if used, shall be mixed in accordance with the manufacturer’s recommendation.

C. The grouting equipment shall produce a grout free of lumps and undispersed cement. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressure of at least 150 psi or twice the actual grout pressures used by the contractor, whichever is greater. The grouting
equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer should be capable of continuously agitating the grout.

D. The grout shall be injected from the lowest point of the drill hole. The grout may be pumped through grout tubes, casing, hollow-stem-augers or drill rods. The quantity of the grout and the grout pressures shall be recorded. The grout pressures and grout takes shall be controlled to prevent excessive heave in cohesive soils or fracturing of rock formations. The entire minipile shall be filled with grout.

E. Upon completion of grouting, the grout tube may remain in the hole but it shall be filled with grout.

F. After grouting, the minipile shall not be loaded for a minimum of three days.

3.02 TESTING

A. A minimum of one test pile shall be loaded to twice the design load. The load test shall be evaluated by the contractor and engineer to assure compliance with job performance requirements.

B. In lieu of reaction piles, two or more anchors may be installed to provide the reaction load. A structural beam certified for the load shall be set and attached to the anchors to complete the reaction assembly.

C. The load shall be applied with a calibrated hydraulic jack. A leveling plate shall be attached to the surface of the test pile and the jack shall be set in position, with the load centered on the pile.

D. The tests shall be performed in accordance with ASTM D 1143-81, Testing of Piles under Axial Compressive Load.

E. The test pile may be a production pile.

F. Contractor guarantees that should the test pile fail to give acceptable results, he will modify his design and install and test another pile at his expense.

3.03 FIELD QUALITY CONTROL

A. Field inspection will be performed under provisions of Section 01 40 00.

3.04 UNACCEPTABLE PILES

A. Unacceptable Piles: Piles that fail tests, are placed out of position, are below cut-off elevations, or are damaged.

B. Provide additional piles or replace piles to conform to specified requirements.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included: Asphaltic concrete pavement required for this work is indicated on the drawings and includes, but is not necessarily limited to:

1. Final preparation of subgrade.
3. Asphalt surfacing materials.

B. Related Work Described Elsewhere:

1. Grading: Section 02210.
2. Excavation, Backfilling, & Compaction: Section 02220.

1.02 QUALITY ASSURANCE

A. Qualifications of Workmen:

1. Provide at least one person who shall be thoroughly trained and experienced in the skills required, who shall be completely familiar with the design and application of work described for this section, and who shall be present at all times during progress of work of this section to direct all work performed under this section.

2. For actual finishing of asphaltic concrete surfaces and operation of the required equipment, use only personnel who are thoroughly trained and experienced in the skills required.

1.03 PRODUCT HANDLING

A. Protection: Use all means necessary to protect asphaltic concrete pavement materials before, during and after installation and to protect the installed work and materials of all other trades.

B. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect and at no additional cost to the Owner.

1.04 DUST CONTROL

A. Use all means necessary to prevent spread of dust during performance of the work of this
section. Thoroughly moisten all surfaces as required to prevent dust from being a nuisance to the public.

PART 2 - PRODUCTS

2.01 MINERAL AGGREGATE (STONE) BASE

Tennessee Department of Highways Specification Section 903.5, Class A, and Specifications Section 303, as adopted January 1, 2015 with Addendums.

2.02 PRIME COAT

Bituminous surface treatments shall meet the provisions of Section 402 and 403 of the Tennessee Highway Department Specifications, revised January 1, 2015.

2.03 HOT-MIX ASPHALT SURFACE COURSE


2.04 HOT MIX ASPHALT BINDER COURSE


2.05 RUNNING TRACK PAVEMENT

A. Construct running track pavement as shown on drawings.

B. Subgrade: Proof-Roll, remove and replace any soft spots and re-compact.

C. Base Course: Tennessee DOT Specifications for Pug-Mill Mix, thoroughly compacted and test for compaction.

D. Surface Course: Sand Sheet (Sand Asphalt), Mix Type VII or Fine Sheet (Sheet Asphalt) Mix Type VIII according to the Asphalt Institute Specifications.

E. Mix Compositions:

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<th>#8</th>
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<td>8-16</td>
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</table>
PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Inspection:
   1. Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.
   2. Verify that asphaltic concrete pavement shall be installed in strict accordance with the original design, all pertinent codes and regulations, and all pertinent portions of the referenced standards.

B. Discrepancies:
   1. In the event of discrepancy, immediately notify the Architect.
   2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 FINAL PREPARATION OF SUBGRADES

A. Refer to drawings for pavement thickness and construction.

B. Subgrade: Constructed to elevations shown on drawings, within a tolerance of 0.10 foot plus or minus under Section 02220, by General Contractor.
   1. Inspect and perform finish grading of subgrade (if required) to the required profiles and grade under this section.
   2. Architect and Contractor shall be informed of deficiencies in the constructed profiles and grade under this section.

C. Aggregate Base Course: Place aggregate base material in compacted layers not more than 4" thick. Compact to not less than 100% of maximum dry density, ASTM D 698, Standard Proctor and construct according to Tennessee Highway Specification 303.

D. Prime Coat: Uniformly apply at rate of 0.20 to 0.50 gal. per square yard cover compacted and clean sub-base surface. Do not flood the surface. Allow to cure and dry. Blot excess with stone chips or sand.

E. Hot Mix Asphalt Surface Course: Place surface course on prepared surface, spread and strike-off using paving machine. Compact with power driven steel roller weighing not less
than 8-tons and according to Tennessee Highway Specifications. Thickness of course to be as shown on drawings. Compact to no less than 92% of its maximum theoretical density.

F. Surface Smoothness: The hot-mix asphalt surface course shall be checked for smoothness with a 10 foot straight edge and a deviation greater than 3/8" will not be accepted.

3.03 PROTECTION

A. Protect from traffic during all operations and until the surface course is thoroughly set and cured.

3.04 FINISH TOLERANCES

Finish all surfaces to the following tolerances:

A. Asphaltic Concrete Plus or Minus 0.05 feet at any point from surfacing: Line and grade shown on the drawings.

3.05 CONCRETE CURBS

A. Certain curbs to be constructed of concrete as shown on drawings. Concrete specifications to be same as given in "Concrete" section of the specifications.

END OF SECTION
SECTION 32 13 16
CONCRETE PAVEMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes exterior cement concrete pavement for the following:
   1. Walkways.
   2. Exterior Steps

B. Related Sections include the following:
   1. Division 31 Section "Earthwork" for sub-grade preparation, grading, and subbase course.
   2. Division 32 Section "Pavement Joint Sealants" for joint sealants of joints in concrete pavement and at isolation joints of concrete pavement with adjacent construction.
   3. Division 3 Section "Cast-in-Place Concrete" for general building applications of concrete.

1.02 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.03 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Qualification Data: For manufacturer.

D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
   1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
   2. Cementitious materials.
   3. Steel reinforcement and reinforcement accessories.
   4. Admixtures.
   5. Curing compounds.
   7. Bonding agent or epoxy adhesive.
   8. Joint fillers.
F. Minutes of pre-installation conference.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.


E. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

F. Mockups: Cast mockups of full-size sections of each concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.
   1. Build mockups 10' x 20' minimum size of each type of concrete paving in the location indicated or, if not indicated, as directed by Architect.
   2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
   4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
   5. Demolish and remove approved mockups from the site when directed by Architect.
   6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
   7. In the event samples are rejected, the Contractor shall prepare samples until accepted by the Landscape Architect.

G. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings."
1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:
   a. Contractor's superintendent.
   b. Independent testing agency responsible for concrete design mixtures.
   c. Ready-mix concrete producer.
   d. Concrete pavement subcontractor.

1.05 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
   1. Use flexible or curved forms for curves with a radius 100 feet (30.5 m) or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.03 STEEL REINFORCEMENT

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

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

C. Plain Steel Wire: ASTM A 82, as drawn.

D. Deformed-Steel Wire: ASTM A 496.

E. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.
F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:
   1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.04 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:

B. Normal-Weight Aggregates: ASTM C 33, coarse aggregate, uniformly graded. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: 3/4 inch (19 mm) nominal.

C. Fine Aggregate: Clean manufactured or natural sand as available locally, free of materials with deleterious reactivity to alkali in cement.

D. Water: ASTM C 94/C 94M.


F. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain no more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.05 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
   1. Available Products:
      a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
      b. Burke by Edoko; Aqua Resin Cure.
      c. ChemMasters; Safe-Cure Clear.
      d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
f. Euclid Chemical Company (The); Kurez DR VOX.
g. Kaufman Products, Inc.; Thinfilm 420.
h. Lambert Corporation; Aqua Kure-Clear.
i. L&M Construction Chemicals, Inc.; L&M Cure R.
k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
l. Symons Corporation; Resi-Chem Clear.
m. Tamms Industries Inc.; Horncure WB 30.
n. Unitex; Hydro Cure 309.
o. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

2.06 RELATED MATERIALS


B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to requirements, and as follows:
   1. Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.07 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

B. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

C. Proportion mixtures to provide normal-weight concrete with the following properties:
   1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
   3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).

D. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   1. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.
   2. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-inch (25-mm) nominal maximum aggregate size.
   3. Air Content: 5 percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.
E. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

F. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

G. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements as follows:
   1. Fly Ash or Pozzolan: 25 percent.
   2. Ground Granulated Blast-Furnace Slag: 50 percent.

2.08 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine exposed sub-grades and sub-base surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared sub-base surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll sub-base in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.

C. Proof-roll with a loaded 10-wheel tandem-axle dump truck weighing not less than 15 tons.
   1. Sub-base with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch require correction according to requirements in Division 31 Section "Earthwork."

D. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and sub-grade is ready to receive pavement.

3.02 PREPARATION

A. Remove loose material from compacted sub-base surface immediately before placing concrete.
3.03 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.04 STEEL REINFORCEMENT

A. General: Comply with CRSI’s "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.05 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

1. Continue steel reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.

C. Butt Joints: Use epoxy bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

D. Keyed Joints: Provide preformed key way-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.

E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate one-half of dowel length to prevent concrete bonding to one side of joint.
F. Isolation/Expansion Joints: Form isolation/expansion joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals of 50 feet maximum, unless otherwise indicated.
   2. Extend joint fillers full width and depth of joint.
   3. Do not continue steel reinforcement across expansion joints
   4. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
   5. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
   6. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
   7. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

G. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows to match jointing of existing adjacent concrete pavement:

H. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a radius noted on the drawings. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

I. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate one-half of dowel length to prevent concrete bonding to one side of joint.

J. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.06 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete form work installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from sub-base surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten sub-base to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site.
F. Do not add water to fresh concrete after testing.

G. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

H. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
   1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer, or use bonding agent if approved by Architect.

J. Screed pavement surfaces with a straightedge and strike off.

K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

L. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified on the plans for machine formed concrete. If results are not approved, remove and replace with formed concrete.

M. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

N. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

O. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and sub-grade just before placing concrete. Keep sub-grade moisture uniform without standing water, soft spots, or dry areas.

3.07 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials: Water.
   a. Continuous water-fog spray.
   b. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.08 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
3. Surface: Gap below 10-foot long, unleveled straightedge not to exceed 1/4 inch.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
7. Joint Spacing: 3 inches.

3.09 FINISHES ON FORMED CONCRETE SURFACES

A. Common finish shall be confined to concrete surfaces which will be covered by other construction and which will not be visible. This finish shall be produced by filling smoothly at tie holes, honeycomb and other depressions, knocking off and evening-up burrs and form marks.

B. A light sand blast finish will be applied to all exposed concrete surfaces. The contractor will produce a sample of the sand blast finish on an area of in-place concrete for approval by the designer prior to proceeding with the rest of the work.

C. A medium broom finish will be applied to all exposed concrete flatwork surfaces. The contractor will produce a sample of the medium broom finish on an area of in-place concrete for approval by the designer prior to proceeding with the rest of the work.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

C. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. or fraction thereof of each concrete mix placed each day.
   1. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.

D. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.

E. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.

F. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
1. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

G. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

H. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

I. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

J. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

K. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

L. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.11 REPAIRS AND PROTECTION

A. Remove and replace immediately, concrete pavement that is broken, damaged, or defective, does not comply with requirements in this Section and in the opinion of the designer does not reasonably match the approved mock up in color, texture, jointing or appearance.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur and protecting concrete pavement with plywood or other covering material.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION
SECTION 32 13 73

PAVEMENT JOINT SEALANTS

PART 1  GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Expansion and contraction joints within cement concrete pavement.
2. Joints between cement concrete and asphalt pavement.

B. Related Sections include the following:

1. Division 32 Section "Concrete Pavement" for constructing joints in concrete pavement.

1.02 SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each type and color of joint sealant required. Install joint-sealant samples in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Product Certificates: For each type of joint sealant and accessory, signed by product manufacturer.

D. Qualification Data: For Installer.

E. Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:

1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for sealants.

1.03 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.
C. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.

1. Use manufacturer's standard test methods to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
2. Submit not fewer than six pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
5. Testing will not be required if joint-sealant manufacturers submit joint preparation data that are based on previous testing of current sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.

D. Product Testing: Obtain test results for "Product Test Reports" Paragraph in "Submittals" Article from a qualified testing agency based on testing of current sealant products within a 36-month period preceding the commencement of the Work.

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 for testing indicated, as documented according to ASTM E 548.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle materials to comply with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.05 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer.
2. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
3. When joint substrates are wet or covered with frost.
4. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
5. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.
PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

2.02 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.03 COLD-APPLIED JOINT SEALANTS

A. Multi-component Jet-Fuel-Resistant Sealant for Concrete: Pourable, chemically curing elastomeric formulation complying with the following requirements for formulation and with ASTM C 920 for type, grade, class, and uses indicated:

1. Urethane Formulation: Type M; Grade P; Class 12-1/2; Uses T, M, and, as applicable to joint substrates indicated, O.
   a. Available Products:
      1) Pecora Corporation; Urexpan NR-300.
      2) Architect approved equivalent

2. Coal-Tar-Modified Polymer Formulation: Type M; Grade P; Class 25; Uses T and, as applicable to joint substrates indicated, O.
   a. Available Products:
      2) Architect approved equivalent

3. Bitumen-Modified Urethane Formulation: Type M; Grade P; Class 25; Uses T, M, and, as applicable to joint substrates indicated, O.
   a. Available Products:
      1) Tremco Sealant/Waterproofing Division; Vulkem 202.
      2) Architect approved equivalent

B. Single-Component Jet-Fuel-Resistant Urethane Sealant for Concrete: Single-component, pourable, coal-tar-modified, urethane formulation complying with ASTM C 920 for Type S; Grade P; Class 25; Uses T, M, and, as applicable to joint substrates indicated, O.

1. Available Products:
   b. Architect approved equivalent
C. Type NS Silicone Sealant for Concrete: Single-component, low-modulus, neutral-curing, nonsag silicone sealant complying with ASTM D 5893 for Type NS.

1. Available Products:
   a. Crafco Inc.; RoadSaver Silicone.
   b. Dow Corning Corporation; 888.
   c. Architect approved equivalent

D. Type SL Silicone Sealant for Concrete and Asphalt: Single-component, low-modulus, neutral-curing, self-leveling silicone sealant complying with ASTM D 5893 for Type SL.

1. Available Products:
   a. Crafco Inc.; RoadSaver Silicone SL.
   b. Dow Corning Corporation; 890-SL.
   c. Architect approved equivalent

E. Multicomponent Low-Modulus Sealant for Concrete and Asphalt: Proprietary formulation consisting of reactive petropolymer and activator components producing a pourable, self-leveling sealant.

1. Available Products:
   b. Architect approved equivalent

2.04 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Sealants: ASTM D 5249, Type 3, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.05 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.03 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install backer materials of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of backer materials.
2. Do not stretch, twist, puncture, or tear backer materials.
3. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.

D. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses provided for each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealants from surfaces adjacent to joint.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
F. Provide joint configuration to comply with joint-sealant manufacturer’s written instructions, unless otherwise indicated.

G. Provide recessed joint configuration for silicone sealants of recess depth and at locations indicated.

3.04 CLEANING

A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations with repaired areas are indistinguishable from the original work.

END OF SECTION
SECTION 32 14 00
PERMEABLE CLAY BRICK PAVERS

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes:

1. Permeable clay brick pavers
2. Stone jointing material
3. Permeable Stone bedding material
4. Open-graded base material

1.02  REFERENCES

A. American Society for Testing and Materials

3. ASTM C448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction
4. ASTM C902 Standard Specification for Pedestrian and Light Traffic Paving Brick

1.03  SUBMITTALS

A. In accordance with General Conditions of the Contract and Division 1 Submittal Procedures Section

B. Permeable Brick Pavers

1. Submit manufacturer’s product literature and material safety data sheets.
2. Submit sample units of each paver type representative of size, shape, color and finish, indicating color variation expected in finished installation. Color or blend of colors will be selected by Landscape Architect from manufacturer’s standard color palette.
   a. Colors within a given shipment of clay pavers will vary slightly due to clay composition and kiln firing temperatures. Such color variations are a natural desirable feature that gives the pavement greater character and depth.
3. Submit test results from approved independent testing laboratory indicating ASTM C902 compliance.
4. Submit manufacturer’s certification of compliance to appropriate ASTM standard.

C. Bedding material, Open-graded Base and Sub Base material
1. Submit sieve analysis results in accordance with [ASTM C136] for jointing, bedding, base and sub-base material.
2. Provide supplier name, source and types of material used for jointing, bedding, base and sub-base.

D. Paving Installer

1. Job references from projects similar in size and design to this project. Provide Owner names, postal address, phone, fax and email address.

1.04 QUALITY ASSURANCE

A. Paving Installer Qualifications

1. Three years experience with at least [15,000] feet of segmental permeable pavers installed.
2. Successful completion of three permeable paver installations similar in design, material and extent indicated on this project. Installer shall have experience setting clay/brick pavers.
3. Successful completion of a Interlocking Concrete Paver Institute permeable paving installation certificate course.

B. Regulatory Requirements

1. Installer shall be able to provide bonds required for the work.

C. Mock-Ups

1. Install a 5 ft by 5 ft area of pavers on a prepared substrate including detail to illustrate component application including pattern and edge details.
2. When required, provide a separate mock-up for each paver type and bonding pattern.
3. Use mock-up to determine pre-compaction setting bed level, joint sizes, lines, laying patterns and product color.
4. Do not start work until mock-up has been approved by Landscape Architect.
5. Approved mock-up is the standard by which appearance, workmanship, substrate preparation and material application will be judged.
6. Approved field sample may be retained as part of finished work. Remove mock-up and dispose of materials when directed by Landscape Architect.

D. Pre-Installation Meetings

1. Conduct pre-installation meeting two weeks prior to commencing work of this section to verify project requirements, substrate condition and coordination with other trades, installation instructions and warranty requirements.
1.05 DELIVERY, STORAGE AND HANDLING

A. Procurement

1. Allow adequate time for the production and delivery of specified paver. Consult local distributor for lead-time and delivery options.

B. Delivery

1. Deliver materials in manufacturer’s original, unopened, undamaged packaging with identification labels intact. Unload pavers with proper equipment so no damage occurs to pavers.

C. Storage

1. Store materials so they are protected from contamination by foreign substances and excessive moisture.
2. Store pavers to prevent damage and staining.

1.06 PROJECT CONDITIONS

A. Environmental Requirements

1. Do not install in rain or snow.
2. Do not install frozen bedding material.

1.07 MAINTENANCE

A. Extra Materials

1. Furnish ten square feet of additional pavers to owner for future maintenance and repair.
2. Pavers shall be from the same production run as the installed materials.

PART 2 PRODUCTS

2.01 PERMEABLE CLAY BRICK PAVERS

A. Permeable Paver Type

1. 4x8x2-3/4 Permeable
   a. Manufactured by Whitacre Greer, 1400 S. Mahoning Ave., Alliance, OH 44601 Telephone: (800) WG PAVER
   b. Band: Cimmerean
   c. Field: Cimmerean
2. Material standard in accordance with ASTM C902.
3. Classification:
   a. Class: SX
   b. Type: I
   c. Application: PS
2.02 AGGREGATE MATERIALS

A. Bedding Course and Joint Filler

1. #89 Crushed stone conforming to ASTM D448
2. Washed with less than 1% passing through the No. 200 sieve.

<table>
<thead>
<tr>
<th>ASTM No. 9</th>
<th>ASTM No. 89</th>
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</thead>
<tbody>
<tr>
<td>Sieve Size</td>
<td>Percent Passing</td>
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<tr>
<td>9.5 mm (3/8 in.)</td>
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<tr>
<td>4.75 mm (No. 4)</td>
<td>95 to 100</td>
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<tr>
<td>2.36 mm (No. 8)</td>
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<tr>
<td>1.18 mm (No. 16)</td>
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<tr>
<td>300 mm (No. 50)</td>
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B. Base Course

1. #57 Crushed stone conforming to ASTM D448
2. Washed with less than 1% passing through the No. 200 sieve.

<table>
<thead>
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<tbody>
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<td>Sieve Size</td>
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<tr>
<td>25.0 mm (1 in.)</td>
</tr>
<tr>
<td>19.0 mm (3/4 in.)</td>
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<tr>
<td>12.5 mm (1/2 in.)</td>
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<tr>
<td>9.5 mm (3/8 in.)</td>
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<tr>
<td>4.75 mm (No. 4)</td>
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<td>2.36 mm (No. 8)</td>
</tr>
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</table>

C. Sub Base Course

1. #2 Crushed stone conforming to ASTM D448
2. Washed with less than 1% passing through the No. 200 sieve.

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<tr>
<td>50 mm (2 in.)</td>
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<tr>
<td>37.5 mm (1-1/2 in.)</td>
</tr>
<tr>
<td>25.0 mm (1 in.)</td>
</tr>
<tr>
<td>19.0 mm (3/4 in.)</td>
</tr>
</tbody>
</table>
2.03 ACCESSORIES

A. Edge Restraints

1. Cast-in-place concrete edge restraint as shown on the drawings.

2. Follow the recommendations of the restraint manufacturer as required

B. Geotextiles

1. Geotextile.
   a. Mirafi 140N Non-woven, polypropylene

2. Physical properties:
   a. Grab Tensile Strength ASTM D4632 120 lbs.
   b. Grab Tensile Elongation ASTM D4632 50%
   c. Trapezoid Tear Strength ASTM D4533 50 lbs.
   d. CBR Puncture Strength ASTM D6241 310 lbs.

3. Manufacturer: Tencate Geosynthetics

C. Geogrid

1 Geogrid.
   a. Tenax LBO SAMP 220, Bi-oriented polypropylene grid

2. Physical properties:
   a. Strength at 2% strain ISO 10319 7.0 kN/m
   b. Strength at 5% strain ISO 10319 14.0 kN/m
   c. Peak Tensile Strength ISO 10319 20.0 kN/m
   d. Yield Point Elongation ISO 10139 11.0 %

3. Manufacturer: Tencate Geosynthetics

PART 3 EXECUTION

3.01 ACCEPTABLE INSTALLER

A. Acceptable paving installer shall have the qualifications listed in these specifications.

3.02 EXAMINATION

A. Verify Site Conditions

1. General contractor shall inspect and certify in writing to installer that site conditions meet the following prior to installation of permeable clay pavers.
   a. Remove organic, unstable or unconsolidated material from the site.
   b. Verify conformance of sub grade preparation and elevations to specified requirements. If CBR (California Bearing Ratio) is less than 5%, typically with clay soils, compaction of sub grade and geotextile may be required.
c. Verify sub base and base conformance to specified requirements. Do not use setting bed material to correct deficiencies in base course surface.

d. Verify written density test results for soil sub grade and sub base course.

e. Verify type, location and elevations of edge restraints, utility structures and drainage inlets.

f. Verify that the [sub base][base] course is ready to support bedding material, permeable pavers and imposed loads.

2. Do not proceed with bedding course or paver installation until satisfactory sub base is verified by contractor.

3. Verify that the area is free from standing water and certified by general contractor as meeting material, installation and grade specifications.

4. Field measurements
   a. Determine actual paver dimensions (including tolerances) and coordinate with dimensions for pavement areas indicated on contract drawings prior to any pavement installation. Adjust pavement area dimensions to eliminate unnecessary paver cutting.

3.03 PREPARATION

A. Edge Restraint Preparation

   1. Install as per drawings at indicated elevations. Interlock geogrid and edge restraints as shown.

B. Aggregate Material

   1. Stockpile joint filler material, base and sub base material such that they are free from standing water, uniformly graded, free of organic mater or sediment, debris, and ready for placement.

3.04 INSTALLATION

A. General

   1. Keep area where pavement is to be constructed free from sediment during entire job. Contaminated sub base, base or bedding material shall be removed and replaced with clean material.

   2. Do not damage drainpipes, overflow pipes, observation wells or any inlets and other drainage elements during installation. Report damage to project engineer.

B. Geotextiles

   1. Install where shown on the drawings.

   2. Place on bottom and sides of soil sub grade. Secure in place to prevent wrinkling from vehicle tires and tracks.

   3. Overlap a minimum of 24 inches in the direction of drainage.
C. Base Aggregate

1. Spread and compact moistened No. 57 base in one 4-inch lift.
   a. Spread in multiple reduced-depth lifts if plate tamper is used for compaction.
2. Make at least two passes in the vibratory mode then at least two in the static mode for each list. A minimum 10-ton vibratory roller should be used. Compact until there is no visible movement of the No. 57 stone.
   a. A plate tamper with 13,500 Lbf may be used for smaller installations.
3. Surface tolerance of No. 57 base stone be +/-1/2 inch over a 10-foot straightedge.

D. Bedding Course Aggregate

1. Spread and screed moistened No. 89 stone bedding material.
2. Fill voids left by removing screed rails with No. 89 stone.
3. Surface tolerance of No. 89 bedding course shall be +/-1/8 inch over a 10-foot straightedge.
4. Do not compact bedding course.
5. Keep pedestrian and vehicular traffic off screeded bedding course until paver installation begins.

E. Permeable Clay Pavers

1. Install paving units in pattern(s) indicated on drawings. Maintain straight pattern lines using string and/or chalk lines.
   a. Maximum bond line variation shall be +/-3/8 inch over a 50-foot string line.
2. Fill gaps at the edges of the paved area with cut units. Cut pavers subject to vehicular traffic shall be no smaller than 1/3 of a whole unit.

F. Joint Material

1. Fill openings and joints between paver units with No. 89 stone.
2. Sweep excess joint material from paved area.
3. Compact pavers into bedding course using low-amplitude plate compactor capable of at least 5,000 lbs centrifugal compaction force.
   Make at least two passes with the plate compactor.
   a. Protect paver surface with mat attached to tamper or other approved method.
4. Do not compact within 6 feet of an unrestrained edge.
5. Apply additional No. 89 stone to joints as required to fill them completely.
6. Pavers within 6 feet of the laying face shall be left fully compacted at the completion of each day.
7. Surface tolerance of finished pavement shall be not more than +/-3/8 inch over a 10-foot straight edge.
8. Surface elevation of finished pavement shall be 1/8 to 1/4 inches above adjacent drainage inlets.
3.05 FIELD QUALITY CONTROL

A. Sweep surface clean and verify conformance with drawings.

B. Verify that adjacent pavers have not more than 1/8 inch difference in height.

C. Verify final elevation of pavement to adjacent drainage inlets.

D. Verify straightness of bond lines.

3.06 PROTECTION

A. After work in this section is complete, General Contractor shall protect work from damage due to subsequent construction activity on site.

END OF SECTION
SECTION 32 16 00

CONCRETE CURBS AND WALKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. All sidewalks, steps, and ramps shall be 4000 psi cast in place concrete with 2” to 4” slump. Concrete shall be 5” thick. Entrained air to be 3% to 6%.

B. Provide light broom finish with smooth troweled joints.

C. Apply two coats of concrete sealer.

D. Comply with Concrete and Reinforcement requirements.

E. Provide construction joints every 4 – 6 feet on center or as shown on drawings. Provide expansion joints every 28 to 30 feet on center, maximum. Construct contraction joints to depth equal to at least 1/4 concrete thickness. Use premolded joint filler for expansion joints. See caulking section for non-tractions self-leveling joint caulking.

END OF SECTION
SECTION 32 31 20
CONSTRUCTION CHAIN LINK FENCING

PART 1  GENERAL

1.01  DESCRIPTION

A. Work Included: Chain link fencing required for this work is indicated on the drawings and includes, but is not necessarily limited to, fence and gates.

1.02  QUALITY ASSURANCE

A. For actual installation of chain link fencing and gates, use only personnel completely trained and experienced in installation of the approved materials and thoroughly familiar with the original design and the approved Shop Drawings.

1.03  SUBMITTAL

A. Within 35 days after award of Contract, and before any chain link fencing materials are delivered to the job site, submit Shop Drawings to the Architect in accordance with Section 01 33 23 of these Specifications.

1.04  PRODUCT HANDLING

A. Protection: Use all means necessary to protect chain link materials before, during, and after installation and to protect the installed work and materials of all other trades.

B. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect and at no additional cost to the Owner.

PART 2  PRODUCTS

2.01  MANUFACTURER

A. Vinyl clad chain link fabric, framework, fittings and accessories shall be manufactured by Semmerling Fence & Supply, Inc. in the U.S.A.

Other approved manufacturers include the following:

1. Anchor Fence Inc.
2. Cyclone Fence Division
2.02 VINYL CLAD FENCE FABRIC

A. General: Fence systems shall have chain link fence fabric supplied with bonded vinyl clad coating over aluminized steel wire, manufactured in accordance with ASTM F668 class 2a or 2b respectively. The fence fabric shall be imprinted with the manufacturer’s trade name, country of origin (USA), ASTM specification (F668), core wire gauge, and finished outside diameter gauge.

B. Steel Core Wire Type: Steel core wire shall have an aluminum coating with a minimum coating weight of 0.20 oz. per square foot.

1. Vinyl Clad Coating: The chain link fence fabric shall have an extruded/bonded vinyl clad costing.
2. Wire Size: Steel core wire size is 9 gauge and the coated wire size is 8 gauge on this project.
3. Height and Mesh Size: Fabric height is 4' or 16' feet high with a mesh size of 2 inches.
5. Color: Color of vinyl coating shall be as chosen from full range of manufactured standard colors.

2.03 STEEL FRAMEWORK

A. General: Fence system shall have fence posts and rails vinyl coated, manufactured in accordance with Federal Specification RR-F-191/3D, Class 1, Grade A or B. Fence systems are to be supplied with vinyl coated fence posts and rails. The frame work for fence systems shall have a 10 to 14 mil coating.

1. Line Posts: Steel pipe shall be 2.375 inches O.D. weighing 3.117 lbs. per lineal ft.
2. End Posts and Corner Posts: Steel pipe shall be 3" inches O.D. weighing 4.640 lbs. per lineal ft.
3. Pull Posts: Stretches of fence more than 500 feet in length shall have one intermediate pull post with braces in both directions. Size and weight of pull post shall be the same as specified for end and corner posts.
4. Gate Posts: Furnish posts to support single gate leaf, or one leaf of a double gate, for the following gate widths:

<table>
<thead>
<tr>
<th>Leaf Width</th>
<th>Gate Post</th>
<th>Weight/Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 6'</td>
<td>3&quot; O.D.</td>
<td>4.64 lbs.</td>
</tr>
<tr>
<td>6' to 13'</td>
<td>4&quot; O.D.</td>
<td>6.56 lbs.</td>
</tr>
<tr>
<td>13' to 18'</td>
<td>6-5/8&quot; O.D.</td>
<td>18.97 lbs.</td>
</tr>
<tr>
<td>18' to 32'</td>
<td>8-5/8&quot; O.D.</td>
<td>28.55 lbs.</td>
</tr>
</tbody>
</table>
5. Top Rail: The top rail shall be supplied in a maximum of 21' lengths joined by 6" long sleeves, and run continuously along the top of the fence through openings provided in the line post tops. The fence fabric shall be fastened to the top rail at intervals of 24" O.C. with fabric ties. Provide means for attaching top rail securely to each gate, corner, end and pull post. Steel pipe shall be 1-5/8" inches O.D. weighing 1.836 lbs. per lineal feet.

6. Brace Rail: Brace rail shall be same size and weight specified for the top rail. Provide means of attaching brace rail securely to each gate, corner, end and pull post. Also use the same attaching method on adjacent line post.

7. Top Tension Wire or bottom Tension Wire: Aluminized steel core wire or galvanized steel core wire size shall be 9 gauge core 6 gauge O.D. on this project. The fence fabric shall be fastened to the tension wire at intervals of 24" O.C. with hog rings. Provide means of attaching tension wire securely to all terminal posts. Color to match fabric and manufacturing coating process.

2.04 FITTINGS AND ACCESSORIES

A. General: All fittings and accessories shall be vinyl coated and manufactured in accordance with Federal Specification RR-F191/4D. Color to match fence fabric.

1. Terminal Post Caps: Aluminum.

2. Line Post Cap: Aluminum.

3. Tension Bars: For 2" and 1-3/4" mesh use 3/16" X 3/4" steel. Bars shall be one-piece lengths up to 12', less 1". Provide one tension bar for each gate and end post, and two for each corner and pull post.

4. Tension Bands: Fabricated from 12 gauge pressed steel. Spaced not over 14" O.C. to secure tension bars to terminal posts. Bands shall have beveled edges.

5. Brace Bands: Fabricated from 12 gauge pressed steel. Bands are to secure rail ends and truss rods to terminal posts. Bands shall have plain edges.

6. Truss Rods: Truss rods shall be 3/8" minimum diameter steel with adjustable takeups.

7. Fabric Ties: PVC coated 9 gauge (0.148") O.D. aluminum core wire.


2.05 GATES

A. General: Fence systems shall have gate frames coated, manufactured in
accordance with Federal Specifications RR-F-191 and shall be vinyl coated.

1. Fence system shall be supplied Grade B pipe. Size and weight of used for gate frame shall have requirements of RR-F-191/2D or 1.90 O.D.

2. Assemble gate frames by using specially designed corner fittings or weld to form a rigid panel. If welded, all welded surfaces shall be coated with epoxy paint, color to match PVC coating on pipe. Frames shall be fitted with the same gauge fabric as the fence. The vertical sides shall be attached by use of tension bands and bars. The horizontal sides shall be attached by use of 9 gauge O.D. tie wires spaced 12” O.C.

B. Hinges:

1. Fence system shall be supplied with size and material to suit gate size, offset to permit 180 degree gate opening. Provide 1 pair of hinges for each leaf and 1-1/2 pair for each leaf and truss rod supports for extra large gates.

C. Latch: Fork latch for single swing gates and plunger-bar type for double swing gates, both to permit operation from either side of gate, with padlock eye as integral part of latch.

D. Drop Rod: To be provided for double swing gates.

E. Keeper: Provide keeper for double swing gates, in order to automatically engage gate leaf and hold it in open position until manually released.

PART 3 EXECUTION

3.01 SURFACE CONDITIONS

A. Inspection:

1. Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

2. Verify that chain link fencing and gates may be installed in strict accordance with the original design and the approved shop drawings.

B. Discrepancies:

1. In the event of discrepancy, immediately notify the Architect.

2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 INSTALLATION

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East Tennessee State University RP2 CONSTRUCTION CHAIN LINK FENCING
A. Install fence in accordance with ASTM Practice F567.

B. Handle all vinyl coated material with care. If vinyl finish is damaged during installation, contractor shall repair or replace material at no cost to the Owner.

END OF SECTION
SECTION 32 31 21
ALUMINUM LOUVER FENCING

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Ornamental fixed louver modular fencing panels fabricated with extruded aluminum louvers and flat aluminum bars including extruded aluminum fence posts and aluminum louver gates.

B. Related sections:
   1. Section 03 30 00 - Cast-in-Place Concrete: Concrete footings for support of fence posts.

1.02  REFERENCES

A. American Society for Testing and Materials (ASTM) Publications:
   1. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
   2. ASTM B221 - Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.
   6. ASTM D3363 - Test Method for Film Hardness by Pencil Test.

1.03  SUBMITTALS

A. Provide in accordance with Division 1 requirements and as described herein.
   1. Product data for components and accessories.
   2. Shop drawings showing layout, dimensions, spacing of components and anchorage and installation details sealed by registrant in the state in which the project is located.
   3. Sample: 18 by 24 inches minimum size sample of fence panel illustrating design, fabrication, workmanship, and selected color coating.
   4. Copy of warranty specified in Paragraph 1.4 for review by Architect.

1.04  WARRANTY

A. Provide in accordance with Section 01 77 70 - Closeout Procedures:
   1. 20 year warranty for factory finish against cracking, peeling, and blistering under normal use.
PART 2  PRODUCTS

2.01  ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, the following product of the listed manufacturer is approved for use on this project:
   1. Ametco® Manufacturing Corporation, 4326 Hamann Parkway, P.O. Box 1210, Willoughby, Ohio 44096; 800-362-1360 is basis of design.

B. Subject to compliance with requirements, equivalent products of other manufacturers may be submitted for the Architect's review and approval.

2.02  MATERIALS

A. Extruded aluminum: ASTM B221, Alloy 6063, Temper T-6.


2.03  FENCE SYSTEM

A. Aluminum Fence System
   1. Ornamental fencing system consisting of horizontal, fixed louver, modular fence panels fabricated with extruded aluminum framing bars and supported by extruded aluminum fence posts; Model: Phoenix Aluminum Fixed Louver Fencing as manufactured by Ametco® Manufacturing Corporation.

B. Fence panel:
   1. Fixed louver bars: Extruded aluminum tube, 1/2 inch x 4 inches wide, spaced at 3-13/16 inches for 100 percent visual screening.
   2. Cross bars: 1/2 by 1/8 inch flat bars welded perpendicular to back side of louver bars and spaced at 18 inches.
   3. Direct Visual Screening shall be 100%.
   4. Panel height: 84" inches unless otherwise shown on approved shop drawings.
   5. Panel width: Varies, see approved shop drawings.
   6. Provide additional support as determined by the manufacturer.

C. Posts: Extruded aluminum solid shapes.
   1. Size: 4 inch by 4 inch or as shown on the approved shop drawings.
   2. Length: As shown on the approved shop drawings.

2.04  GATES

A. Provide gates of type and size indicated on Drawings. Equip gates with manufacturer's standard hardware as required for complete functional operation.

B. Type: Hinged swinging double gates.
   1. Construction: Welded frame fabricated from extruded aluminum tubing as determined by the manufacturer with aluminum fixed louver panels to match fencing material all as shown on the approved shop drawings.
2. Nominal leaf sizes: 72” wide by 84” high; 60” wide by 84” high; 36” wide by 84” high.

3. Hardware:
   a. Hinges: Size and type as determined by manufacturer. Provide 2 hinges for each leaf up to 6 feet high and 1 additional hinge for each additional 24 inches in height or fraction thereof.
   b. Latch: 3/4 inch diameter slide bolt to accommodate padlock.
   c. For double gates provide padlockable, 5/8 inch diameter center cane bolt assembly and strike.

2.05 ACCESSORIES

A. Fasteners: Stainless steel bolts of type, size, and spacing as recommended by fence manufacturer for specific condition.

2.06 FACTORY FINISH

A. Aluminum fence panels and posts shall receive polyester powder coating. Large gate panels shall be coated with 2-part polyurethane coating.

B. Polyester powder coating: Electrostatically applied colored polyester powder coating heat cured to chemically bond finish to metal substrate.
   1. Minimum hardness measured in accordance with ASTM D3363: 2H.
   2. Direct impact resistance tested in accordance with ASTM D2794. Withstand 160 inch-pounds.
   3. Salt spray resistance tested in accordance with ASTM B117: No undercutting, rusting, or blistering after 500 hours in 5 percent salt spray at 95 degrees F and 95 percent relative humidity and after 1000 hours less than [3/16 inch] [5 mm] undercutting.
   4. Weatherability tested in accordance with ASTM D822: No film failure and 88 percent gloss retention after 1 year exposure in South Florida with test panels tilted at 45 degrees.

C. Polyurethane coating: 1.0 mil dry film thickness of coating of test panel cured 30 minutes at 180 degree F and aged 14 days shall resist the following test conditions without failure:
   1. 5 percent salt spray for 500 hours.
   2. 100 percent relative humidity for 1000 hours.
   3. Water immersion for 100 hours.
   4. 20 double rubs with cloth saturated with either lacquer thinner, acetone, MEK, gasoline, xylene.
   5. Exposure to lubricating oils, hydraulic fluids, and cutting oils.
   6. 16 cycles of 24 hours at 100 percent humidity, 24 hours at 10 degrees F, and 24 hours at 77 degrees F.
   7. Hardness: H to 2H.
   8. Flexibility: [1/8 inch] [3 mm] conical mandrel.

D. Color: Selected by Architect from manufacturer's standard range.
PART 3  EXECUTION

3.01  PREPARATION

A. Prior to fabrication, field-verify required dimensions.

B. Cast concrete footings in accordance with Section 03 30 00 - Cast-in-Place Concrete as detailed on Drawings and approved shop drawings.
   1. Minimum footing diameter:
      a. Terminal and gate posts: 12 inches.
      b. Intermediate line posts: 10 inches.
   2. Allow 36 inches minimum embedment of posts.
   3. Allow 6 inches minimum concrete beneath post bottom.

3.02  INSTALLATION

A. Install fencing in accordance with manufacturer's installation instructions and approved shop drawings.

B. Install fence posts plumb and level by embedding post directly in concrete footing. Temporarily brace fence posts with 2 by 4 wood supports until concrete is set.

C. Do not install bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.

D. Secure fence panels with standard stainless steel bolts to fence posts after posts have been set in footings.

E. Gates:
   1. Install gates and adjust hardware for smooth operation.
   2. Provide concrete center foundation depth and drop rod retainers at center of double swinging gate openings.

F. Touch-up damaged finish with paint supplied by manufacturer and matching original coating.

END OF SECTION
SECTION 32 91 19

TOPSOILING AND FINISHED GRADING

PART 1  GENERAL

1.01  DESCRIPTION

A. General:

1. Furnish all labor, materials, tools, equipment, and services for all topsoiling and finished grading, as indicated, in accord with provisions of Contract Documents.

2. Completely coordinate with work of all other trades.

3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

4. See Division 1 for General Requirements.

B. Related Work Specified Elsewhere:

1. Excavation, Backfilling & Compaction: Section 31 22 00
2. Grading: Section 31 22 10
3. Erosion & Sediment Control: Section 31 25 00

C. Location of Work: All areas within limits of grading and all areas outside limits of grading which are disturbed in the course of the work.

1.02  QUALITY ASSURANCE

A. Finish Grading Tolerance: 0.1 FT (30 mm) plus/minus from required elevations.

1.03  SUBMITTALS (See Section 01 33 23)

A. Shop Drawings: Not required.

B. Product Data: Not required.

C. Samples: Not required.

D. Project Information: Not required.
PART 2  PRODUCTS

2.01  MATERIALS

A. Topsoil: Original fertile, friable surface soil typical of the area, capable of supporting native plant growth, reasonable free of subsoil, clay, weeds, roots, and stones larger than 1 IN.

PART 3  EXECUTION

3.01  ROUGH GRADE REVIEW

A. Rough grading reviewed by Architect in Section 31 22 10, Grading.

3.02  PREPARATION

A. Correct, adjust and/or repair rough graded areas.
   1. Cut off mounds and ridges.
   2. Fill gullies and depressions.
   3. Pre-form other necessary repairs.
   4. Bring all sub-grades to specified contours, even and properly compacted.

B. Loosen surface to depth of 2 IN (50 mm), minimum.

C. Remove all stones and debris over 2 IN (50 mm) in any dimension.

3.03  PLACING TOPSOIL

A. Do not place topsoil when subgrade is either wet or frozen enough to cause clodding.

B. Spread topsoil to compacted depth of 6 IN (100 mm) for all disturbed earth areas, except areas covered by buildings, paving, walks, sediment basins, rip-rap and areas not disturbed.

C. Make finished surface free of stones, sticks, or other material 1 IN (25 mm) or more in any dimension.

D. Make finished surface smooth and true to required grades.

E. Restore areas occupied by stockpiles to condition of rest of finished work.
3.04 ACCEPTANCE

A. Upon completion of topsoiling, obtain Architect's acceptance of grade and surface.

B. Make test holes where directed, to verify proper placement and thickness of topsoil.

END OF SECTION
SECTION 32 92 19

SODDING, SEEDING AND GROUND COVER

PART 1  GENERAL

1.01   DESCRIPTION

A. General:

1. Furnish all labor, materials, tools, equipment, and services for all sodding, seeding and ground cover as indicated, in accord with provisions of Contract Documents.

2. Completely coordinate with work of all other trades.

3. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a complete installation.

4. See Division 1 for General Requirements.

5. Related Work Described Elsewhere:

   a. Grading: Section 31 22 10
   b. Erosion & Sediment Control: Section 31 25 00
   c. Topsoiling and Finish Grading: Section 32 91 19

B. Location of Work: Temporary erosion control by seeding on all areas indicated, which are not occupied by other planting or construction. Sod all areas noted on drawings. Ground cover on sloped embankments where noted on drawings.

1.02   SUBMITTALS (See Section 01 33 23)

A. Shop Drawings: Not required.

B. Product Data: Not required.

C. Samples: Not required.

D. Project Information:

   1. Certificates for sod stating botanical and common names and percentages of each species percentage of purity. Certificate of quality.

   2. Copies of invoices for all fertilizer used on project, showing grade furnished, to determine total quantity applied.

1.03 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver fertilizer in original container, labeled with content analysis.

1.04 JOB CONDITIONS

A. Perform sodding during conditions conducive to successful results.
   1. Provide proper and adequate protection.
   2. Do not lay when temperature is below 32° degrees F. (0° degrees C).
   3. Do not lay in frozen or dried out soil.
   4. Do not place frozen or dried out sod.
   5. Lay within 24 hours of stripping.

PART 2 PRODUCTS

2.01 MATERIALS

A. Establish a smooth, healthy, uniform close stand of sod.

B. Sod: Viable, dense, strongly rooted, not less than 2 years old.
   1. 60 percent Kentucky Bluegrass, 30 percent Fescue and 10 percent of other grasses.
   2. Free of weeds and undesirable native grasses.
   3. Strips 12” to 18” inches (300 to 450 mm) wide.
   4. Mow prior to stripping from field.
   5. Cut sod 3/4” inches (18 mm) of soil is firmly attached to roots.
   6. Not frozen or dormant.

C. Fertilizer: Commercial fertilizer of 5-10-5 analysis, meeting applicable requirements of State and Federal Law.
   1. Do not use cyanamic compounds or hydrated lime.

D. Water for Planting Purposes: Supplied by Owner. Provide all equipment necessary to transport water from source to required locations. Do not waste water.
PART 3 EXECUTION

3.01 SOIL PREPARATION

A. Limit preparation to areas which will be planted soon after preparation.

B. Loosen surface to minimum depth of 4" inches (100 mm).

C. Remove stones and debris over 1" inch (25 mm) in any dimension.

D. Distribute fertilizer uniformly over areas to be sodded at rate of 30 lb./1,000 s.f. (0.14 kg/sm).
   1. Use suitable distributor.
   2. Incorporate fertilizer into soil to depth of at least 2" inches (50mm).

E. Clean surface of substances which will interfere with turf development or subsequent mowing operations.

F. Grade areas to smooth, even surface with loose, uniformly fine texture.
   1. Roll and rake, remove ridges and fill depressions, as required to meet finish grades.
   2. Fine grade just prior to planting.

G. Restore areas to specified condition if eroded or otherwise disturbed between fine grading and planting.

H. If fertilizer application rate is determined (by invoices submitted) to be less than that specified, apply additional fertilizer.

3.02 SODDING

A. Lay to form solid mass with tightly filled joints.
   1. Butt ends and edges; do not overlap.
   2. Stagger joints.
   3. Blend sod into seeded areas.

B. Tamp or roll lightly to ensure full contact with subgrade.

C. Work sifted soil into minor cracks, avoid smothering adjacent grass.

D. Peg sod on slopes to prevent slippage.
1. Use sharpened 1 x 1 x 6 inches (25 x 25 x 150 mm) wooden pegs.

3.03 SEEDING (Temporary)
A. After all areas to be seeded are graded and topsoil has been placed, experienced men shall sow seed with adequate equipment at a time when little or no wind is blowing.
B. Seed with annual rye grass at the rate of 3-5 lbs. per 1,000 square feet.
C. Hydro-Seeding is an acceptable method of seeding areas:
   1. Prepare soil as for seeding.
   2. Apply a mixture of fiber, specified seed, 16-16-8 fertilizer 15 lbs./1,000 square feet, and water with an approved hydraulic sprayer.
   3. Keep mulch and seed out of ground cover areas and off walks and areas to be paved. Clean up these areas.

3.04 GROUND COVER (Crown Vetch)
A. Provide Crown Vetch ground cover where noted on drawings.
B. Apply at the rate of 3-5 lbs. per 1,000 square feet with companion seeds of annual rye 3-5 lbs. per 1,000 square feet and Kentucky 31 3-5 lbs. per 1,000 square feet.
C. Apply 12-24 fertilizer at 1,000 lbs. per acre.

3.05 MAINTENANCE
A. Maintain grassed area for 30 days after planting.
   1. Water, fertilize, weed, mow, trim, roll, regrade, replant as required.
   2. Establish a smooth, healthy, uniform, close stand, free of eroded or bare areas, weeds and surface irregularities.
B. Provide and maintain temporary piping, hoses and watering equipment as required to keep seeded areas uniformly moist for proper growth.
   1. Lay out temporary watering system and arrange watering schedule to avoid walking over muddy and newly sodded areas.
   2. Prevent puddling and water erosion and displacement of sod.
C. Mow seeded areas as soon as there is enough top growth to cut with mower set at recommended height for principal species planted.

1. Repeat mowing as required to maintain height.
2. Do not delay mowing until grass blades bend over and become matted.
3. Do not mow when grass is wet.
4. Time initial and subsequent mowings as required to maintain height of 1-1/2” to 2” inches (37 to 50 mm).
5. Do not mow lower than 1-1/2” inch (37 mm).

D. Resod bare, dead or dying areas using same materials specified.

END OF SECTION
SECTION 32 93 00

TREES, SHRUBS, AND GROUND COVERS

PART 1 GENERAL

1.01 SUMMARY

A. Provide and furnish all trees, shrubs and ground covers, labor, miscellaneous materials and equipment required or inferred from drawings and specifications to complete the work of this section.

1.02 SUBMITTALS

A. Certification:
1. Submit certificates of inspection for all plant materials with project close-out documents and as required by governmental authorities.
2. Submit manufacturer’s or vendor’s certified analysis for soil amendments and fertilizer materials. Submit other data substantiating that materials comply with specified requirements.

B. Notice of Sources:
Within 15 days following the award of Contract, the Landscape Architect shall be notified in writing of the sources of all plant materials for this project. This notification shall include an itemized list of all plant materials and the complete address and telephone number of the supplier of each plant. Any requests for plant material substitution shall be included with this notification. Requests for substitution will not be considered before or after this notification.

C. Specimen Plant Material Photography
Contractor must locate, photograph or videotape from both sides with a scale figure, and tag at the source each individual plant material labeled "Specimen" in the Plant Legend. The Contractor must furnish photographs of each individual plant and inform Landscape Architect in writing of the source/location at least ten (10) days prior to digging. Subsequently the Landscape Architect may, at his discretion, inspect and seal specimen plant materials before digging. In the event plant material is found to be unacceptable the Contractor will pursue other sources until acceptable plant material is found, at no additional cost to the owner. The contractor will reimburse the owner for time and travel costs incurred by the Landscape Architect ($650.00 per day plus travel costs) because of requested inspections of unacceptable specimen plant materials. Approval at the plant source does not impair the right of inspection and rejection during the progress of the work.

D. Planting Schedule:
Submit planting schedule showing scheduled dates for each type of planting work in each area of site. Submit planting schedule prior to beginning of the work. Planting schedule shall demonstrate a thorough understanding of the overall project schedule in accordance with the requirements of this specification section and good horticultural practices of the area in which the project is located.
E. Maintenance Instructions:
Upon completion of the installation, submit typewritten recommendations for maintenance of any portion of the landscape which, in the opinion of the Contractor, requires special attention.

F. Topsoil Sample:
Submit one cubic foot of topsoil proposed for use, two (2) weeks prior to beginning work. If topsoil source changes submit sample from new source.

G. Soil Test Report:
Submit results of laboratory soil tests two (2) weeks prior to beginning of the work. If topsoil source changes submit soil test report from new source.

H. Approval:
Obtain approval from Landscape Architect in writing for all submittals including miscellaneous materials prior to beginning of work.

I. Miscellaneous Materials:
Submit product literature and samples of all miscellaneous materials required to complete the work of this section.

J. Provide plant material record drawings:
1. Legibly mark drawings to record actual construction.
2. Identify field changes of dimension and detail and changes made by Change Order referenced to permanent surface improvements.

1.03 QUALITY ASSURANCE

A. Applicable Standards:
1. Plant names indicated, comply with "Standardized Plant Names" as adopted by the latest edition of the American Joint Committee of Horticultural Nomenclature. Names of varieties not listed conform generally with names accepted by the nursery trade. Provide stock true to botanical name and legibly tagged.
2. Provide stock true to botanical name and legibly tagged. Characteristics of individual plant species shall be as described in "Hortus Third". The character of individual plant varieties not listed shall be as defined in current horticultural literature and practice.

B. General:
All plants shall be grown in a recognized nursery in accordance with good horticultural practice. Provide healthy stock free of disease, insects, eggs, larvae and defects such as knots, sun scald injuries abrasions or disfigurement.
C. Tree Sources:

The design was based upon trees obtained from the following nursery sources and all trees shall be obtained from the following nursery sources unless otherwise approved by the Landscape Architect during bidding:
1. Select Trees Inc.
2. Hunter Trees
3. Bold Spring Nursery
4. Landscape Architect approved equivalent nursery prior to bidding only.

D. Substitutions:
Do not make substitutions. If specified plant material is not obtainable, submit to Landscape Architect proof of non-availability and proposal for use of equivalent material. For proof of non-availability submit a written statement from a minimum of 6 reliable nursery sources (American Nurserymen’s Association Members) that the plant in question is not obtainable in the Eastern United States.

E. Analysis and Standards:
Package standard products with manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made accordance with methods established by the Association of Official Agriculture Chemists, wherever applicable.

F. Topsoil:
Before delivery of topsoil, furnish Landscape Architect with written statement giving location of properties from which topsoil is to be obtained, depth to be stripped, and, if applicable, crops grown during past 2 years.

G. Soil Test Report:
Contractor shall engage a reputable laboratory to include testing and analysis of soils representative of planting areas on site and new topsoil with reference to specified plant materials. The soil test report should provide the following data: Water pH; soil test ratings for Phosphorus, Potassium, Calcium, Magnesium, Zinc, Iron and Manganese; percentage of organic matter; soluble salts; recommendations on type and quantity of additives required to establish satisfactory pH factor and supply nutrients to bring nutrients to satisfactory level for planting specified plant materials.

H. Approval and Selection of Materials and Work:
The selection of all materials and the execution of all operations required under the specifications and drawings is subject to the approval of the Landscape Architect. The Landscape Architect has the right to reject any and all materials and any and all work which, in the opinion of the Landscape Architect does not meet the requirements of the Contract Documents at any stage of the operations. The Contractor shall promptly remove rejected work and or materials from job site. The Contractor shall replace rejected work and or materials promptly.
1.04 DELIVERY, STORAGE AND HANDLING:

A. Deliver fertilizer materials in original, unopened, and undamaged containers showing weight, analysis, and name of manufacturer. Store in manner to prevent wetting and deterioration.

B. Shipment and Delivery:
Promptly notify the Landscape Architect in advance, when the plant material is to be delivered and the manner of shipment; (2) furnish therewith an itemized list of the actual quantity and sizes; (3) deliver the necessary inspection certificates to accompany each plant or shipment prior to acceptance and planting; (4) when shipment is made by truck, pack all plant material to provide adequate protection against climate and breakage during transit and tie to prevent whipping; (5) cover the tops with tarpaulin to minimize wind whipping and drying, or spray adequately with anti-transparent; (6) exercise care at all times during the handling operations to prevent damage to bark, branches, and root system; (7) employ a suitable method of handling to insure the careful workmanlike delivery of heavy balled plants to preclude cracked plant balls. No balled plant shall be planted if the ball is cracked or broken either before or during the planting operation.

C. Protection After Delivery:
The balls of "B & B" plants which cannot be planted immediately on delivery shall be covered with moist soil or mulch, or other protection from drying winds, sun, and freezing temperatures. Rooted plants shall be planted or heeled in immediately upon delivery. All plants shall be watered as necessary until planted.

D. Do not remove container grown stock from containers until planting time.

E. Label at least one tree and one shrub of each variety with a securely attached waterproof tag bearing legible designation of botanical and common name.

F. Do not remove labels attached to plant material until directed by the Landscape Architect to do so.

1.05 PROJECT CONDITIONS

A. Work notification:
Notify Landscape Architect at least 7 working days prior to installation of plant material.

B. Protect existing utilities, paving, and other facilities from damage caused by landscaping operations.

C. Proceed with and complete landscape work as rapidly as portions of site become available, working within seasonal limitations for each kind of landscape work required. Schedule delivery of plant materials to closely coincide with installation and to minimize stored plant materials. All stored plant materials shall be protected, maintained and subject to all provisions of this specification.

D. Existing Utilities:
The Contractor shall--at his own expense--locate, excavate and verify the
alignment and depth of all underground utilities as shown on the drawings. Perform work in a manner which will avoid possible damage. Maintain grade stakes set by others unless removal is mutually agreed upon by parties concerned. All damage to utilities resulting from work covered in these specifications will be repaired at the Contractor's expense.

E. Excavation:
When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, adverse soil conditions or obstructions, notify Landscape Architect in writing before planting.

F. Planting Time:
1. Plant or install materials during suitable weather conditions.
2. A dormant season planting is required.

G. Planting Schedule:
Submit proposed planting schedule to Landscape Architect. Schedule dates for each type of landscape work during contract period.

H. Out-of-Season Planting:
Out-of-Season planting shall not be permitted unless approved in writing by Landscape Architect. If an out-of-season planting is anticipated Contractor shall submit in writing the program for out-of-season planting including digging schedules, temporary nursery location, maintenance methods and procedures for stored plant material and proposed planting dates. Out-of-season planting program shall be submitted to Landscape Architect no later than November 1 in advance of the dormant digging season.

I. The irrigation system will be installed prior to planting. Coordinate all work with irrigation trade contractor as required. Locate, protect and maintain the irrigation system during planting operations. Repair irrigation system components damaged during planting operations.

1.06 WARRANTY

A. Warrant all trees, shrubs and ground covers against defects including death and unsatisfactory growth in the opinion of the Landscape Architect. Warrant trees shrubs and ground covers for one (1) year from the date of Substantial Completion of the entire project.

B. Replace in accordance with the drawings and specifications, all plants that are dead or, as determined by the Landscape Architect, are in an unhealthy or unsightly condition, and have lost their natural shape due to dead branches, or other causes. The cost of such replacement(s) is at Contractor's expense. Warrant all replacement plants for one (1) year after installation.

C. Warranty shall not include damage or loss of trees, plants, or ground covers caused by fires, floods, freezing rains, lightning storms, or winds over 75 miles per hour, winter kill caused by extreme cold and severe winter conditions not typical of planting area; acts of vandalism or negligence on the part of the Owner.
D. Remove and immediately replace all plants, as determined by the Landscape Architect, to be unsatisfactory during the initial planting installation and one year warranty period.

E. Replacements:
   Match adjacent specimens of same species. Replacements are subject to all requirements stated in this specification and subject to inspection by the Landscape Architect.

F. Repair grades, paving and any other damage resulting from replacement planting operations, at no additional cost to the Owner.

G. Inspect job site monthly during warranty period to determine what changes, if any, should be made in the maintenance program. Submit all recommended changes in writing to the Landscape Architect and the Owner. In the absence of monthly written reports from the Contractor it shall be assumed that the Contractor is satisfied with the Owner’s maintenance operations and procedures and waives any and all claims for damages against the Owner with respect to the warranty requirements of this specification.

H. At the close of the warranty period, one (1) year after Substantial Completion of Trees, Shrubs, and Groundcovers work, notify the Owner and Landscape Architect in writing of the date for warranty inspection. Make any repairs or replacements identified by the Landscape Architect in the Warranty Inspection.

I. Upon satisfactory completion of repairs and/or replacements the Landscape Architect certifies, in writing, the final acceptance of the work.

PART 2  PRODUCTS

2.01 TOPSOIL
   Topsoil:
   New topsoil shall be fertile, friable, natural surface soil of fine to medium textured loamy character. Topsoil should be representative of the dark brown surface soils in the vicinity which produce heavy growth. The topsoil shall be reasonably free from subsoil, objectionable weeds, litter, sod, stiff clay, stones larger than one inch in any dimension, stumps, roots, weeds, toxic substances, or any other material which may be harmful to plant growth or hinder planting operations. Topsoil shall exhibit the following characteristics as evidenced by the soil test report: Water pH 6.5 minimum, phosphorus 9-30 pounds per acre, potassium 45-160 pounds per acre, organic matter 2.5% minimum, soluble salts 0-1060 parts per million. Obtain topsoil only from naturally, well drained sites where topsoil occurs in a depth of not less than four inches. Topsoil shall not be delivered in a frozen or muddy condition. The furnishing of all topsoil needed for planting and soil mix will be considered a subsidiary portion of this specification and covered in the cost of trees, shrubs, and ground covers.

2.02 SOIL AMENDMENTS

   A. Fertilizer shall be a mixed commercial fertilizer, of Grade 10-10-10 or as recommended by the Soil Report with guaranteed chemical analysis of contents
marked on containers or sacks.

B. Lime:
Ground or pulverized of horticultural grade capable of neutralizing soil acidity and containing not less than 85% of total carbonates. Containers or sacks shall be labeled to show chemical and mechanical analysis.

2.03 PLANTING SOIL MIX

A. Planting soil mix shall be provided amended as per soils test report recommendations. Basic soil mix is as follows:

- 80% Topsoil (as specified)
- 10% Peat
- 10% Sand
- Fertilizer as recommended by Soils Report
- Lime as recommended

2.04 PLANT MATERIALS

A. General:

1. A complete list of plants including a schedule of sizes, quantities, and other requirements is shown on the drawings. In the event that quantity discrepancies or material omissions occur in the plant materials list, the planting plans shall govern.

2. Specific requirements concerning plant material and the manner in which it is to be supplied are shown on the drawings and plant list.

3. Acclimatization: Plants must have grown under climatic conditions and temperature extremes similar to those of the locality of the project site for a minimum of two years immediately prior to being planted on the job.

B. Quality and Size:

1. Plants shall have a habit of growth that is normal for a well maintained sample of the species and shall be sound, healthy, vigorous and free from insect pests, plant diseases, and injuries. Plants to be selected for specific branching habit where a range of habit occurs within a species shall be furnished thickly branched as noted on the plant list. All plants shall equal or exceed the measurements specified in the plant list, which are minimum acceptable sizes. They shall be measured before pruning with branches in normal position. Pruning shall be done at the discretion of or as directed by the Landscape Architect, but in no case shall the plants supplied under this contract be pruned back to such an extent that they no longer meet specifications. Requirements of plants in the plant list generally follow the code of standards currently recommended by the American Association of Nurserymen, Inc., in the American Standard of Nursery Stock.

2. Collected Plant Material. (Plants which are not nursery grown). Plant material shall be collected only if specifically authorized in writing by the Landscape Architect. Any collected plant material which is authorized shall be dug with a ball of earth which has a diameter at least 1/3 greater...
3. Plants furnished shall be at least the minimum size indicated. Larger stock is acceptable, at no additional cost, and providing that the larger plants will not be cut back to size indicated. Provide plants indicated by two measurements so that only a maximum of 25% are of the minimum size indicated and 75% are of the maximum size indicated.

4. Specimen Plant Material: Plants labeled "Specimen" in the plant list shall be outstanding plants of the species and shall be of the highest quality possessing all the characteristics shown in the plant materials list.

5. Furnish plants to match as closely as possible whenever symmetry is called for.

6. Balled and Burlapped Plants: All plants designated "B &B" on the plant list shall have firm natural balls of soil in sizes as set forth in the "American Standard for Nursery Stock" and shall be: (1) wrapped firmly with burlap or approved material; (2) bound carefully with twine, cord or wire mesh, in a manner so as not to damage the bark, break branches, or destroy natural shape; (3) covered with moist soil, mulch, or other protection from drying if not planted immediately. Cracked or mushroomed balls are not acceptable.

7. Bare Root Plants: Plants designated "BR" in the list of plants to be furnished shall be dug with substantially all of the root system intact, and with the earth carefully removed from the roots. Cover all roots with a thick coating of mud by puddling, or otherwise protect from drying after they are dug.

8. Container grown plants in cans or plastic containers will be acceptable in lieu of balled and burlapped plants provided that they are of specified quality. The container must be removed prior to planting, care being exercised as to not injure the plant.

C. Trees

1. Provide trees of height and caliper listed or shown and with branching configuration recommended by ANSI Z60.1 for type and species required. Provide single stem trees except where special forms are shown or listed.

2. Determining dimensions for trees are caliper, height and spread. Caliper taken 6" above ground for trees up to and including 4" caliper. Trees over 4" caliper measure 12" above ground. Height and spread dimensions specified refer to the main body of the plant and not from branch tip to tip. Take measurements with branches in normal position.

3. Evergreen trees shall be branched to the ground.

4. No pruning wounds shall be present with a diameter of more than 1" and such wounds must show vigorous bark on all edges.

D. Shrubs

1. The measurements for height shall be taken from the ground level to the average height of the top of the plant and not the longest branch. Single stemmed or thin plants will not be accepted.

2. Side branches shall be generous, well-twigged, and the plant as a whole well-bushed to the ground.

3. Plants shall be in a moist, vigorous condition, free from dead wood,
bruises, or other root or branch injuries.

E. Ground Cover
Provide good ground cover plants established and well-rooted in removable containers or integral peat pots and with not less than minimum number and length of runners by ANSI Z60.1 for the pot size shown and as listed in plant list.

F. Perennials
1. Provide perennial bulbs, corms and tubers which are fleshy and free of rot and not less than the grade and size recommended by ANSI Z60.1 for the size shown or listed.
2. Provide good perennials in either a dormant condition or actively growing. Actively growing perennials shall be furnished rooted in removable containers or field dug. Field dug perennials shall be in a moist, vigorous condition with no sign of desiccation.

2.05 MISCELLANEOUS LANDSCAPE MATERIALS

A. Burlap for wrapping earthball to be biodegradable jute mesh not less than 7.2 oz. per square yard.

B. Anchors: “Duck Bill” Better Bilt model #EC88 large earth anchors capable of holding from 300 to 3000 pounds as distributed by A.M. Leonard Co. (1-800-543-8955) and Ben Meadows Co. (1-800-241-6401), 2 x 2 or better uniform grade pressure treated pine, or sound new hardwood or redwood free of knot holes and other defects.

C. Guy: ArborGuy rootball guying system from Green Blue urban.
www.greenblue.com

D. Hose: 1/2” diameter black reinforced rubber or plastic garden hose, cut to required lengths to protect tree trunks from damage by wires. Used hose is acceptable.

E. Soil Separator: Rot resistant polypropylene filter fabric, water permeable, and unaffected by freeze-thaw.

F. Drainage Gravel: Clean 3/4” crushed stone.

G. Water transportation is the sole responsibility of the Contractor.

H. Mulch:
1. All planting areas unless otherwise noted shall receive Pine Straw. Fresh, bearing bright brown color and free of weeds, grasses or other debris. Pine straw mulch shall be aged one year prior to use to create the preferred Carbon to Nitrogen ratio.
2. In Bio-swale areas: Temperature stabilized 6 month old well-rotted shredded native hardwood bark mulch not larger than 4” in length and 1/2” in width, free of woodchips, sawdust recycled wood waste, fine composted or dyed mulches.
I. Tackifier:
Liquid concentrate diluted with water forming a transparent 3--dimensional film like crust permeable to water and air and containing no agents toxic to seed germination. Use tackifier on Bio-swale mulch to hold mulch in place prior to permanent planting.
Available Manufacturers and types:
Polybind DLR: Celtite, Inc., Cleveland, OH
Curasol AK: American Hoechst Corp., Elk Grove, IL

J. Anti-Desiccant: Protective film emulsion providing a protective film over plant surfaces; permeable to permit transpiration. Mixed and applied in accordance with manufacturer's instructions.

K. Pre-Emergence Herbicide for general use shall be "Ronstar", "Casaron", or approved equal. Apply at the rates, times and manner recommended by the manufacturer.

L. Guy Cable and Turnbuckles: Stranded steel cable not less than 1/4" diameter with galvanized steel turnbuckles of size and gauge required to provide tensile strength equal to that of cable. Turnbuckle openings shall be 3" minimum. Provide cable clips and accessories as required to complete the guying operations.

PART 3 EXECUTION

3.01 PREPARATION

A. General

1. Contractor must examine conditions under which planting is to be installed. Review applicable architectural and engineering drawings, and be familiar with alignment of underground utilities before digging.

2. Planting Time: Planting operations are to be performed at such times of the year as the job may require, with the stipulation that the Contractor guarantees the plant material as specified herein. Plant only during periods when weather conditions are suitable.

3. Layout individual tree and shrub locations and areas for multiple plantings. Stake locations and outline areas and secure Landscape Architect's acceptance before start of excavation for planting work. Make adjustments as may be requested.

4. Notify Landscape Architect before planting in writing of adverse sub-surface drainage or soil conditions. State conditions and submit a proposal for correction including costs. Obtain approval for method of correction prior to continuing work in the affected area. In the event that alternate locations are selected, the Contractor will prepare such areas at no additional expense to the Owner.

5. Planting shall be performed only by experienced workmen familiar with planting procedures under the supervision of a qualified supervisor.

3.02 EXCAVATION
A. Preparation of Tree and Shrub Pits:

1. Excavate pits with vertical sides, as specified and as shown on the drawings. For balled and burlapped (B & B) trees and shrubs, make excavations at least half again as wide as the ball diameter and equal to the ball depth.
2. Loosen hardpan and moisture barrier to a depth of 2' minimum below the bottom of the tree pit or until hardpan has been broken and moisture is allowed to drain freely. For shrub pits, loosen hardpan 8" minimum below bottom of excavation or until hardpan has been broken and moisture is allowed to drain freely.
3. For container grown stock, excavate as specified for balled and burlapped stock, adjusted to size of container width and depth.
4. Conduct drainage tests.
5. During planting process fill planting pit excavation to final grade using planting soil mix.

B. Test Drainage:

1. Acceptable Drainage Rate
Minimum acceptable percolation rate for tree pits, shrub pits and shrub/ground cover beds shall be 0.10 inch per hour.
2. Tree and Shrub Pits:
Fill each pit with water. If percolation is less than 0.10 inch per hour in a 24 hour period, drill a 12" auger to a depth of four feet below the bottom of the pit. Fill auger hole with 3/4" stone and cover with soil separator. Re-test pit. In case drainage is still unsatisfactory, notify Landscape Architect, in writing, of the condition before planting in such questionable areas. If not, Contractor is fully responsible for warranty of trees.

C. Dispose of subsoil removed from landscape excavations. Do not mix with planting soil, use as backfill or use to construct saucers around plant pits.

3.03 PREPARATION OF PLANTING SOIL MIX

A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful or toxic to plant growth.

B. Mix specified soil amendments and fertilizers with topsoil at rates specified. Delay mixing of fertilizer if planting will not follow placing of planting soil within a few days.

C. For pit and bed type backfill, mix planting soil prior to backfilling.

3.04 PLANTING TREES AND SHRUBS

A. Pit Planting: Set plants on 6" of backfill soil mix to such depth that the finished grade level at the plant after settlement will be the same as that at which the plant has grown. They shall be planted upright and faced to give the best appearance or relationship to adjacent structures. No burlap shall be pulled out from under balls. Platforms, wire and surplus binding from top and sides of the
balls shall be removed. Roots shall be spread in their normal position. All broken or frayed roots shall be cut off cleanly. Soil shall be placed and compacted carefully to avoid injury to roots and to fill voids. When the hole is nearly filled, add water as necessary and allow it to soak away. Fill the hole to finish grade, and form a shallow saucer around each plant by placing a ridge of topsoil around the edge of each pit. After the ground settles, additional soil shall be filled into the level of the finished grade.

B. Bed Planting: Install 8" approved topsoil in all areas to be planted with shrubs, groundcovers, perennials, mass plantings, etc. Set plants in backfill soil mix to such depth that the finished grade level at the plant after settlement will be the same as that at which the plant has grown. They shall be planted upright and faced to give the best appearance or relationship to adjacent structures. No burlap shall be pulled out from under balls. Platforms, wire and surplus binding from top and sides of the balls shall be removed. Plants shall be removed from containers. Roots shall be spread in their normal position. All broken or frayed roots shall be cut off cleanly. Soil shall be placed and compacted carefully to avoid injury to roots and to fill voids. When planting is finished, add water as necessary and allow it to soak away. After the ground settles, additional soil shall be filled into the level of the finished grade.

C. Form shallow saucers to the finished grade outside the tree pit approximately 4" - 6" height capable of holding water about each plant by placing a mound of topsoil around the edge of each filled-in pit.

D. If deciduous trees or shrubs are moved in full leaf, spray with anti-desiccant at nursery before moving and again after planting as per manufacturer's recommendations.

E. Mulching:
Immediately after planting work has been completed, mulch pits, trenches and planting beds. Provide not less than 3" thickness of pine straw mulch at all locations where mulch is required except color beds. Provide not less than 1" of shredded pine bark at all annual and perennial beds. Hold mulch 4 inches away from tree trunks. Apply/incorporate pre-emergence herbicide per manufacturer's instructions. Finish edges according to detail.

F. Water:
Soak all plants immediately after planting, continue watering thereafter as necessary until acceptance of the work in total.

G. Smooth planting areas to conform to specified grades after full settlement has occurred and mulch has been applied.

3.05 STAKING, GUYING AND PRUNING:

A. Stake and guy trees immediately after planting. Plants shall be plumb after staking or guying. Maintain stakes, wires and guys until acceptance of the work in total.

B. Staking trees of 1" to 3" caliper.
   Drive stakes securely into ground and fasten to tree with wire and tie. Use
hose around wire so wire is not in contact with plant. Adhere to staking details unless alternate detail has been approved by Landscape Architect prior to beginning of planting operation.

C. Staking trees of 1" and under or 4' height:
Use single stake with rubber hose and wire loop around trunk.

D. Guy deciduous trees over 3" to 5" caliper and evergreen trees 4'-8' all as described and detailed. Position guys around trunk at approximately two-fifths the height of the tree. Anchor guys in ground either to steel rods driven securely into ground with top end 3" below finish grade or steel anchors securely screwed into ground with top end at or below finished grade. Use hose around wire to prevent wire from coming in contact with tree. Flag all guy wires as required.

E. Guy deciduous trees over 5" caliper and evergreen trees over 8' tall as described and detailed. Install 3 screw anchors minimum equally spaced around the tree at approximately two-fifths the height of the tree. Securely anchor cable to screw anchors. Use hose around cable so cable is not in contact with plant. Secure cable around tree trunk. Securely attach ends of cable to turnbuckle so that cable is taut before adjusting turnbuckle. Flag all guy cables as required.

F. Pruning:
Unless otherwise directed by the Landscape Architect do not cut tree leaders, and remove only injured or dead branches from trees, if any. Prune shrubs at the direction of the Landscape Architect.

G. Remove and replace promptly any plants pruned or misformed resulting improper pruning.

I. Paint wounds and cuts over 3/4" in diameter with approved tree paint designed for this purpose.

3.06 MAINTENANCE:

A. Begin maintenance immediately after planting.

B. Maintain trees, shrubs and other plants until Substantial Completion of the entire project and for not less than 60 days after Substantial Completion of the entire project.

C. Maintain trees, shrubs and other plants by watering, pruning, cultivating, weeding, and re-mulching as required for healthy growth. Restore planting saucers. Tighten and repair stake and guy supports and reset trees and shrubs to proper grades or vertical position as required. Restore or replace damaged wrappings. Spray as required to keep trees and shrubs free of insects and disease.

3.07 CLEAN UP AND PROTECTION:

A. During landscape work, keep pavements clean and work area in an orderly condition.
B. Upon completion of work, clear grounds of debris, superfluous materials and all equipment. Remove from site to satisfaction of Landscape Architect.

C. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed, at no additional cost to Owner.

3.08 SUBSTANTIAL COMPLETION AND FINAL COMPLETION

A. Upon completion of work, notify Landscape Architect at least ten (10) days prior to requested date of inspection for Substantial Completion. Contractor shall prepare a list of incomplete work and submit the list with the request for inspection. Remove rejected plants and materials from project site prior to inspection.

B. Landscape Architect will review the work and document incomplete or incorrect work in an inspection report or list. If Trees, Shrubs, and Groundcovers work is found to be substantially complete a Certificate of Substantial Completion will be issued that establishes a date of substantial completion. The list of incomplete or incorrect work will be attached to the Certificate.

C. Complete or correct Trees Shrubs and Groundcovers work identified on the list within the number of days established in the Certificate of Substantial Completion.

D. Upon satisfactory completion of repairs and/or replacements, the Landscape Architect certifies, in writing, the Final Completion of the work.

END OF SECTION
SECTION 33 05 00

COMMON WORK RESULTS FOR UTILITIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. General provisions of the Contract, General and Supplementary Conditions, and General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

A. Provide labor, materials, equipment, and services necessary to install sanitary sewer, underground cold water and appurtenances, and related items, including trenching and backfilling, required to complete the work indicated on drawings, outside of buildings.

B. All work specified in this section is from a point 5 feet outside the building walls.

1.03 PERMITS AND CODES

A. Work shall comply with all applicable codes and regulations.

1.04 SUBMITTALS

A. Furnish to Designer, affidavits from manufacturers of pipe, pipe coating, fittings, valves, and meters furnished and installed under this Section, certifying that such materials delivered to the project conform to requirements of this specification.

1.05 LOCAL STANDARDS

A. Contractor shall contact utility company prior to bidding to determine local standards regarding approved piping materials for the municipality involved.

B. Term, "local standards", as used herein, means the standards of design and construction of respective municipal (or county) department or utility company.

1.06 EXISTING UTILITIES

A. Maintain in operating condition all active utilities, encountered in utility installation. Repair to satisfaction of Owner surface or sub-surface utilities damaged during course of work, unless such utility is shown to be abandoned or removed.
PART 2  PRODUCTS

2.01  WATER DISTRIBUTION SYSTEM MATERIALS

A. Pipe Materials - Domestic Water:

1. Cold water piping 4" and under shall be seamless copper tubing, type K, complying with ASTM B88. Fittings shall be wrought copper or cast bronze solder joint.

B. Pipe Materials - Fire/Water Main:

1. Water pipe outside building larger than 4" shall be Ductile iron pipe, class 350, conforming to AWWA C151, and shall have 350 psi minimum pressure rating, push on joint type. All ductile iron pipe shall have AWWA Specification C104 standard thickness bituminous sealed cement mortar lining and bituminous outside coating. Fittings for Ductile Iron Pipe shall be mechanical type with standard thickness bituminous sealed cement mortar lining, bituminous outside coating, and ends as required for the types of joints specified or indicated for the various pipe locations and applications.

C. Valves:

1. All valves and stops shall have ends suited, or adapters shall be provided, for proper installation in lines in which they are located.

2. Valves 2-inch and larger shall be iron-body, bronze or brass mounted double gate valves conforming to AWWA standard specifications C-500. They shall open in same direction as those used in local water works system. Valve stems shall terminate in wrench nuts. Furnish two suitable keys.

3. Valve boxes for 2-inch and larger valves shall be approved standard cast iron, adjustable shaft boxes having minimum shaft diameter of 5-1/2". Castings shall be coated with two coats of coal tar pitch varnish. Lids of all boxes shall bear word "Water", or letter "W".

D. Meter Vault, Water Meter, and Fire Flow Tap:

1. Prior to bidding, contact local utility company to determine their participation, if any, for providing or installing main taps, water meter, and meter vault, and to obtain fees charged by utility company. Contractor shall pay all costs for utility connections and appurtenances charged by utility companies.

2.02  SANITARY SEWER

A. Pipe and Fittings - Sanitary Sewer

1. Pipe for sanitary sewer shall be Schedule 40 PVC with DWV fittings for all piping 6" or smaller.
2. Pipe larger than 6" shall be SDR-35, 3034 PVC pipe and fittings.

3. Manufactured from virgin, National Sanitation Foundation (NSF) approved resin conforming to ASTM D-1784.

4. Unless otherwise specified, all PVC pipe and fittings shall conform to ASTM F-789.

5. The gaskets used for joining PVC sewer pipe shall conform to ASTM F-477.

6. All PVC gravity sewer pipe shall be clearly marked with the Manufacturer's name, nominal diameter, SDR, ASTM D-3034 designation, and NSF approved seal.

2.03 CLEANOUTS

A. Cleanouts shall be 4" raised head brass plug type set in pre-cast concrete valve ring, with 4" cast iron soil pipe and fittings from cleanout down to the horizontal piping, all conforming to the applicable requirements of WASTE, VENT, AND SOIL PIPEING, herein-before. See detail on site-utilities drawings.

2.04 SEWER STRUCTURES - SANITARY - MANHOLES, PRE-CAST

A. AASHTO M-199 SR OR ASTM C-478.

B. Manhole Inverts: Construct manhole flow channels of concrete, and of semi-circular section conforming to inside diameter of connecting sewers. Make changes in size or grade gradually and change in direction by true curves. Provide such channels for all connections to each manhole.

C. Openings shall be provided for the required number and size pipes and shall be marked to insure installation at proper locations.

D. Use o-ring joints or "Mastic" joint in accordance with ASTM C-443 or ASTM C-361 at all joints between sections in sanitary sewer manholes.

E. Use Type II cement for increased sulfate resistance.

F. Provide manholes with lift holes that do not completely penetrate the wall of manhole sections.

G. Manhole bases for depths greater than 15' are to be double reinforced wire mesh with a minimum height of 1' of concrete above the pipe opening. Steel in all manhole sections over 15' should meet ASTM C-76 class II or higher. Base sections for manholes over 15' should have an extended bottom slab.
H. Casting for Frame and Covers:

1. Castings for manholes, shall comply with local standards. Castings for sewer structures shall be of tough even grained, soft gray iron class 30, free from burnt-on sand and other injurious defects, and of approximate weight and dimensions shown on drawings. Before leaving foundry, castings shall be thoroughly cleaned, subjected to hammer test for soundness, and given two coats of coal tar pitch varnish. Tops and gratings weighing less than 100 pounds shall have approved locking device.

2. Frames and covers for use on watertight manholes shall be machined to a smooth uniform bearing complete with polyvinyl gasket set inside the bolt circle that will provide a watertight seal.

3. All frame openings shall be full 24" diameter to provide clear access conforming to OSHA regulations.

4. Steps in sewer structures shall conform to local standards and be polypropylene plastic molded around a steel rod, 300 pound live load, with top surface of minimum 10" cleat designed to prevent foot slippage and be a minimum of 4" from wall.

5. Castings by John Bouchard, Neenah, or approved equal.

6. All structures shall conform to Johnson City standards.

2.05 PIPE ENTRANCE COUPLINGS FOR MANHOLES

A. Connections between pipes and manholes shall be watertight, made with flexible gaskets and meeting quality standards of ASTM C-443. Internal aluminum band material shall conform to specification 6061-T6, T651. External band shall be 304 Stainless Steel conforming to ASTM Specification A-167. Use Kom-N-Seal Boot, PSX Boot, or equivalent. Provide connection for all pipes including service connections.

2.06 CHECK DAMS

A. Check dams shall be installed in the bedding and backfill of all new or replaced sewer lines to limit the drainage area subject to trench drain effect of gravel bedding. Major rehabilitation projects should also include check dams in the design. Dams shall consist of compacted clay bedding and backfill at least three feet thick to the top of the trench and cut into the walls of the trench two feet. Alternatively, concrete may be used, keyed into the trench walls. Dams shall be placed no more than 500 feet apart.
2.07 NATURAL GAS

A. Contractor shall contact Atmos Energy in Johnson City to determine costs for installation of high pressure gas main, tap, and meter/regulator station at the building and include all costs in bid.

2.08 BACKFLOW PREVENTION

A. Backflow preventer on site shall be reduced pressure zone type with OS & Y gate valves and tamper switches. RPZ shall be installed in an above ground environmental enclosure with insulated panels and slab heater. See detail on drawings.

PART 3 EXECUTION

3.01 TRENCHING AND BACKFILLING

A. Backfill and compact all depressions resulting from clearing and grubbing with suitable materials.

1. Backfill embankment areas to natural ground elevation.

2. Backfill excavation areas below finished subgrade to finished subgrade.

B. Perform backfilling a satisfactory distance ahead of construction operations.

C. Prepare areas designated on the drawings to receive erosion control matting to smooth surfaces that have been shaped, fertilized and seeded.

D. Protection:

1. Protect all private roads and walks and maintain them during course of work. Repair all damage at Contractor’s expense.

2. Erect a wooden barricade around all excavations before starting work.

3. Provide and maintain guard lights at all barricades, railings, obstructions in streets, roads, or sidewalks, and at all trenches or pits adjacent to public walks or roads.

4. Remove and replace at Contractor’s expense all work damaged by failure to provide required protection.

E. Width of Trench - Excavate trenches of sufficient width for proper installation of work. When depth of backfill over piping exceeds 10 feet, keep trench below level of top of pipe as narrow as practicable.
F. Separate Trenches - Unless otherwise shown or required, provide separate trenches for sewer and water lines. Shelving of water lines above sewer lines is not acceptable. At crossings, water piping must be on top with a minimum of 18” separation between the bottom of the water line and the top of the drainage line. See “Water and Sewer Separation” detail on drawings.

G. Sheeting, Bracing, Water Removal:

1. Sheet and brace trenches, and remove water as necessary to fully protect workmen and adjacent structures and permit proper installation of work. Comply with local regulations or, in absence thereof, with provisions of “Manual of Accident prevention in Construction”, of AGC. Under no circumstances lay pipe or install appurtenances in water; keep trench free from water until pipe joint material has hardened. Presence of ground water in soil or necessity of sheeting or bracing trenches shall not constitute a condition for which any increase may be made in the Contract price.

2. Sheeting left in place shall be cut off not less than 2 feet below finished grade. Sheeting shall not be removed until trench is substantially backfilled.

H. Excavation and Bedding - Excavate all pipe trenches to at least six inches below bottom elevation of pipe at all points. Grade trench bottom evenly. Refill bottom of trench with six inches of washed stone for polyvinylchloride and ductile iron piping.

Utilize sand for bedding of copper domestic water line. Make bell holes. Lay piping. Check to see that piping bears uniformly for full length. Refill bell holes or voids and compact bedding. Necessity of refill material shall not constitute a condition for which an increase may be made in Contract Price. Minimum trench width shall be 18” plus outside diameter of pipe bell.

I. Backfilling - Backfill trenches only after piping has been inspected, tested, approved, and location of pipe and appurtenances have been recorded. Backfill by hand around pipe and for a depth of one foot above pipe; use stone to 6” above PVC pipe and sand to 12” above top of domestic cold water copper pipe. See “Water and Sewer Pipe Bedding” details on drawings. Tamp firmly in layers not exceeding 6” in thickness, taking care not to disturb pipe or injure pipe coating. Compact earth for remainder of backfill thoroughly with a rammer of suitable weight or with an approved mechanical tamper. Under pavement, walks, and other surfacing, pipe shall be backfilled completely with crushed stone. Exclude all cinders and rubbish from trenches in which pipes are laid. Compact backfill in trenches.

3.02 DEBRIS REMOVAL

A. Promptly remove cleared debris from site.

B. For disposal of debris, refer to Special Waste Disposal Requirements Documents.
3.03 EXCAVATION TRENCHES

A. Perform in such a manner as to form a suitable trench in which to place the pipe and so as to cause the least inconvenience to the public.

B. Maximum width at the crown of the pipe should be wide enough for 6" rock on each side of the pipe. With trench depth greater than 5', the trench should be 4' wide to accommodate a ditch box or other shoring.

C. Align trench as show on the Plans unless a change is necessary to miss an unforeseen obstruction.

D. When unstable soil is encountered at the trench bottom, remove it to a depth required to assure support of the pipeline and backfill to the proper grade with coarse aggregate AASHTO M-43, Size No. 2 or 3.

E. Remove rock encountered in trench excavation to a depth of 6 inches below the bottom of the pipe barrel, backfill with an approved material, and compact to uniformly support the pipe. In no case shall solid rock exist within six (6) inches of the finished pipeline.

F. When rock borings or soundings are provided, they are for information only and do not guarantee existing conditions. Make such investigations as deemed necessary to determine existing conditions.

3.04 GRAVITY SANITARY SEWER BEDDING

A. Always maintain proper grade and alignment during the bedding and tamping process.
   1. Any pipe dislodged during this process shall be replaced.
   2. Dig bell holes to assure uniform support of the pipe.

B. Bedding for PVC Sewers:
   1. Completely encapsulate each sewer pipe section with granular material from a distance of 6" below the bottom of the pipe to a distance of 6" above the top of the pipe for the entire width of the ditch, compacted to 60% relative density, ASTM D-2049. Use Class I angular material.

3.05 INITIAL BACKFILLING

A. Do not begin backfilling before the Designer has inspected the grade and alignment of the pipe, the bedding of the pipe, and the joints between the pipes. If backfill material is placed over the pipe before an inspection is made, reopen the trench in order for an inspection to be made.
B. Perform backfilling by hand, together with tamping, until fill has progressed to 18" above the top of the pipe.

1. Deposit Class I granular material (where required) or loose soil free from lumps, clods, frozen material or stones in layers approximately 6" thick.

2. Compact by hand or with manually operated machine tampers actuated by compressed air or other suitable means.

3.06 FINAL BACKFILLING

A. Backfill material up to three feet above the top of the pipe should not exceed 6 inches in diameter at its greater dimension.

B. After the backfill has reached a point 18" or more above the top of the pipe, perform final backfilling depending upon the location of the work and danger from subsequent settlement.

C. Backfilling in Unimproved Areas:

1. Dispose of and replace all soft or yielding material which is unsuitable for trench backfill with suitable material.

2. Deposit backfill to the surface of the ground by dragline, bulldozer, or other suitable equipment in such a manner so as not to disturb the pipe.

3. Neatly round sufficient surplus excavated material over the trench to compensate for after settlement.

4. Dispose of all surplus excavated material, per Special Waste Disposal Document Requirements.

5. Prior to final acceptance, remove all mounds to the elevation of the surrounding terrain.

D. Backfilling Beneath Driveways and Streets where Non-Rigid and Rigid Type Surfacing is to be Replaced:

1. Use select backfill material, crushed limestone, or crushed gravel of high weight and density.

2. Carefully deposit in uniform layers, not to exceed 12" thick, compacted to at least 95 percent standard proctor but not less than a minimum of 90 lb/ft³ dry density.

3. Compact each layer thoroughly by rolling, ramming and tamping with tools suitable for that purpose in such a manner as to not disturb the pipe.
3.07 WATER DISTRIBUTING SYSTEM INSTALLATION

A. Connections to Existing Mains - Contractor shall make arrangements with Local Utility Co. for connection to existing water main, installation of service, meter and meter box, and valves and valve boxes. Installation shall be in accordance with requirements of the Utility Co. and Contractor shall pay all costs. Provide written acceptance from Water Utility Company.

B. Handling and Storing Materials - Unload cast iron pipe by hoists or skidding so as to avoid shock or damage. Handle and store all pipe in such manner as to avoid deformation or other injury thereto. Place no pipe within pipe of a larger size. Store pipe and fittings on sills above storm drainage level and deliver for laying after trench is excavated. Valves and hydrants shall be drained and so stored as to protect them from freezing.

C. Pipe Laying: General - Interior of pipe shall be clean and joint surfaces wiped clean and dry when pipe is lowered into trench. Hammer-test cast iron pipe for soundness before lowering. Lower each pipe, fitting and valve into trench carefully and lay true to line and without objectionable breaks in grade. Insert a water tight plug in open end of piping when pipe laying is not in progress.

D. Fittings and Branch Connections - Install suitable fittings at all changes in directions, dead ends, and branch connections.

E. Setting Valves - Before setting each valve make sure interior is clean and test opening and closing. Set valve and stops with stems plumb and at exact locations shown. Provide a brick laid flat or other similar foot piece under each curb box. Valve and service boxes shall be plumb with tops at finished grade.

F. Blocking - Pour concrete thrust blocks per requirements of NFPA 24 Table 9605 between undisturbed trench face and plugged ends, and bends, to prevent pipe movement at joints; where soil is not firm, provide in lieu of concrete, approved tie rods and collars, painted with coal tar pitch varnish after placing.

G. Insulated Fitting and Wrapping - Where copper pipe connects to cast iron pipe or other ferrous pipe, provide a brass electrically insulated fitting. Wrap fitting and copper pipe for two feet from fitting with dielectric tape.

H. Tests - Before joints are covered, fill piping with water, opening hydrants or other outlets as necessary for expelling entrapped air. Thereafter, furnish necessary equipment and test piping, under supervision of Local Authority, for a period of at least 2 hours at a pressure of 150 pounds per square inch. Inspect all joints, and remedy to satisfaction of Local Authority any defects discovered. Continue tests until all visible leaks, except as hereinafter specified, have been eliminated from part of system under test.
I. Flushing Mains - Immediately upon completion of water distribution system test all valves to insure their full opening and flush out system as follows: Open fire hydrant nearest connection to existing system and permit flow to continue until water runs clear. Thereafter, repeat operation at next hydrant and proceed in order to hydrant farthest from source of supply. Use outlets in buildings to flush upper ends of mains and service lines. During such flush operation Local Authority may test flows from hydrants and, before final acceptance of work, make further tests of hydrant flows to ascertain if lines are clear.

J. Sterilization of Water Distribution System - As soon as water distribution system has been flushed out as above specified, it shall be sterilized by following or other method satisfactory to Local Authority.

1. Introduce chlorine or a solution of calcium or sodium hypochlorite, filling lines slowing and applying sterilizing agent at a rate of 50 parts per million of chlorine, as determined by residual chlorine tests at end of lines. Open and close all valves and hydrants while system is being chlorinated.

2. After sterilizing agent has been applied for 24 hours, test for residual chlorine at end of lines. If less than 5 p.p.m is indicated, repeat sterilization process.

3. When tests show at least 5 p.p.m. of residual chlorine, flush out system until all traces of chemical used are removed.

4. Local Authority reserves right to test water again at any time prior to final acceptance of work, if found unsafe bacteriologically, to require Contractor to re-chlorinate system until water is proven equal to that supplied by public system.

3.08 SEWER CONNECTION

A. Sewer Pipe Laying:

1. Commence at lowest point in system and lay pipe with bell or groove end upgrade. Test pipe for soundness and clean interior and joint surfaces before lowering pipe into trench. Lay pipe in straight lines and on uniform grades between points where changes in alignment or grade are shown. Bed pipe barrel uniformly (see "Trenching and Backfilling" above).

Check line and invert grade of each pipe from a top line carried by batter boards not over 25 feet apart. Fit pipe to form a smooth uniform invert. Laser beam method for obtaining alignment and grades is also approved. All testing shall be approved before backfilling is started.
B. Flushing Sewers:

1. Flush all sanitary sewers, except building connections, with water in sufficient volume to obtain free flow through each line. Remove all obstructions and correct all defects discovered. Remove all silt and trash from catch basins and inlets just prior to final acceptance of work.

3.09 INITIAL PROOF TESTING OF SANITARY SEwers

A. It is the intent to specify a “test as you go” procedure in order to establish confidence in the installation and avoid the unnecessary delay of final acceptance.

B. Before a reach of pipeline is approved for payment, successfully proof test that reach for grade, alignment, cleanliness, and leakage.

C. In the event that four or more reaches fail to satisfactorily pass proof testing procedures, cease pipe laying until deficiencies are identified and corrected.

D. The basis for grade, alignment and cleanliness testing will be visual inspection. Leakage testing will be by means of low pressure air as specified hereinafter.

1. Proof test flexible pipeline inhalation for deflection by pulling a “go-no-go” test mandrel through the line after the initial backfill has been in place at least 24 hours. No pipe shall exceed a deflection of 5%. The test shall be run with a rigid ball or an engineer-approved 9-arm mandrel having a diameter equal to 95% of the inside diameter of the pipe. The test must be performed by manually pulling the test device through the line.

E. Manholes will be inspected and tested by the Designer before or during incorporation in the work. However, the inspection and testing of manholes shall not relieve the Contractor of the responsibility for furnishing material that conforms to the specifications. The Owner may retest all materials that have been accepted at the source after delivery and may reject those that do not conform to the specifications. Stored manholes may be re-inspected prior to use. Work in which untested manholes are used without the written permission of the Designer may be considered unacceptable.

3.10 FINAL TESTING

A. Before the job is accepted and before house services are connected, a final testing procedure is to be followed.

B. All sewers and manholes shall be built practically watertight and the Contractor shall adhere rigidly to materials and workmanship. After completion of certain line segments, the Contractor shall immediately air test sections thereof. If leakage is above limits specified, the sewer will be replaced. The Owner may request infiltration/exfiltration tests after project completion on selected line segments but all line shall be first air tested.
C. Prior to acceptance of completed sewer lines, the lines shall be inspected and tested to ensure compliance with the following provisions. After the sewer lines have been brought to completion and prior to final inspection, the Contractor shall clean out the downstream segments. Each individual line will be cleaned by pushing appropriate tools from manhole to manhole to remove any and all debris and obstructions or may, if possible, flush clean with water or remove by hand. Water may be turned into the system to determine whether the completed lines are true to line and grade as laid out or as shown on the drawings. All lines or sections of lines that are laid with improper line or grade, that contain broken sections of pipe, that are obstructed in such a manner that they cannot be satisfactorily corrected otherwise, or are deflected in excess of the allowable, shall be removed and replaced.

D. Low Pressure Air Test: Test entire system as follows:

1. The section of sewer to be tested shall have been backfilled.

2. Both ends of the pipe section being tested shall be sealed airtight.

3. Pressurize the sealed pipe to 4 psig above the average back pressure of ground water over the sewer pipe at the time of the test and allow the air pressure to stabilize for at least two minutes.

4. After the stabilization period, adjust the pressure to 3.5 psig and measure the time in minutes and seconds for the pressure to drop to 2.5 psig. If ground water is present, the starting air pressure shall be increased to 3.5 psig above the level of the ground water and the time measured.

5. The time measured for the pressure drop to occur shall be not less than that shown in the following table:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Time for Length Shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>Less Than 100'</td>
</tr>
<tr>
<td>8&quot;</td>
<td>7:34</td>
</tr>
</tbody>
</table>

E. Repair or replace any line that fails any of the above tests and retest.

F. Sewer service assemblies shall be installed and capped at locations directed by the Designer, and shall be included in Final Testing.

G. All test shall be witnessed by the Inspector representing the Johnson City Water and Sewer Services Engineering Department.
H. Vacuum Testing for Manholes

All precast manholes including frames shall be vacuum tested as follows:

1. Manholes should be tested after assembly and prior to backfilling.

2. All pipe openings shall be plugged by pneumatic or mechanical plugs and braced to sustain 10" mercury vacuum. The rim to cone joint shall be tested on all manholes with watertight covers. No one shall be inside the manhole during testing. The test shall be at 10 in. mercury.

3. Installation and operation of vacuum equipment and indicating devices shall be in accordance with equipment specification for which performance information has been provided by the manufacturer and approved by the City of Johnson City Water and Sewer Services Department.

Minimum Time to Hold 1 in. Mercury Drop

<table>
<thead>
<tr>
<th>MH Dia.</th>
<th>MH Height</th>
<th>Hg(minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4'</td>
<td>10' or less</td>
<td>1 in. 1 min. 0 sec.</td>
</tr>
<tr>
<td>4'</td>
<td>10-15'</td>
<td>1 in. 1 min. 15 sec.</td>
</tr>
<tr>
<td>4'</td>
<td>15-25'</td>
<td>1 in. 1 min. 30 sec.</td>
</tr>
</tbody>
</table>

4. If the manhole fails the test, necessary repairs shall be made and the vacuum test and repairs shall be repeated until the manhole passes the test or the manhole shall be tested in accordance with the standard exfiltration test and rated accordingly. All leaks shall be sealed from the outside of the manhole. No visible leaks shall be observed inside the manhole.

3.11 SEWER MANHOLES - GENERAL

A. Unless otherwise specified, all manholes shall have an inside diameter of not less than 4 feet and a vertical wall height of not less than 2.5 feet.

B. The clear opening in the manholes shall be not less than 2.0 feet.

C. Depth of the manhole shall be the vertical distance from the lowest invert in the manhole to the top of the frame and cover assembly.

D. Backfill manholes with the same material used for pipelines.

E. Mechanically tamp Class I material a distance of at least on full pipe length to prevent settlement of pipelines.

F. Frame and cover shall not be installed in curb lines.
3.12 STANDARD PRECAST CONCRETE MANHOLES

A. ASTM C-478, with o-ring joints or "Double Mastic" joints in accordance with ASTM C-433 or ASTM C-361 and manufacturer’s recommendation. Use Type II cement.

B. The base of the manhole shall be Class C concrete not less than 8" in depth with inverts not less than 4" depth.

C. Shape manhole inverts from Class B concrete to be smooth, accurately shaped, and in accordance with the Plans. Inverts shall be of such shape and slope to provide smooth transition between inlet and outlet sewers and to minimize turbulence. Channeling height shall be to the spring line of the sewers. Benches shall be sloped from the manhole wall toward the channel to prevent accumulation of solids.

D. Inlets and outlets from each manhole shall drop 0.10 foot across the manhole and shall be finished smooth and flush with the sides of the manhole walls so as not to obstruct the flow of liquid through the manhole.

E. When possible, the base of the manhole shall sit on dry, consolidated and undisturbed soil.

F. When wet or unconsolidated material occurs or when over-excavation of the base occurs, provide a subbase with minimum of 12" of Class I, granular material, well compacted with mechanical tamping equipment.

G. When completed the manhole shall be free from channel obstructions and leakage.

H. Use of concrete grade rings will be limited to a vertical height of eight to twelve inches, with joints between each ring sealed with preformed gasket material.

I. If manhole does not pass vacuum test then all section joints shall be grouted inside and outside.

J. All manholes shall be vacuum tested prior to backfilling operations.

3.13 MANHOLE STEPS

A. Materials for manhole steps should be highly corrosion resistant meeting ASTM C-478 standards. The use of galvanized steel should be avoided and aluminum or plastic with reinforcing bar is preferred.

B. Set manhole steps at intervals of 15 inches along the wall of the manhole.

C. The treads of the steps shall be free from mortar or other material when the manhole is completed.

D. In precast manholes, the holes left to receive the steps shall be mortared smooth following placement of the steps.
E. Steps shall be installed in a straight line.

F. Steps shall be oriented in plain view to accommodate proper positioning of frame and cover.

3.14 MANHOLE FRAMES AND COVERS

A. Seal manhole frames and covers in place with mastic.

B. The bearing surfaces between cast frames and covers shall be machined, fitted together, and match marked to prevent rocking.

C. All castings shall be of the types, dimensions and weights as shown on the plans and shall be free of faults, cracks, blowholes, or other defects.

3.15 DROP MANHOLE ASSEMBLIES

A. Drop manhole assemblies shall be constructed as outlined on the plans.

B. The material used in the drop pipe construction shall be ductile iron and class “B” concrete.

C. Concrete shall completely encase the drop to a height of 2’ above bend to prevent dislodging.

D. Inside drops will be used only where shown on the plans or specifically approved by the Johnson City Water and Sewer Services Engineering Department.

3.16 FINAL INSPECTION

A. At time of final inspection of work performed under Contract, utilities covered by this Division shall be complete in every respect and in perfect operating condition. All surplus material of every character resulting from the work of the Division shall have been removed. Sanitary and storm sewers shall be free from sand, silt or other obstructions. Any defects discovered in the utilities to this inspection shall have been corrected. City of Johnson City shall be notified for inspections.

END OF SECTION
SECTION 33 27 20
SITE DRAINAGE SYSTEM

PART 1  GENERAL

1.01  WORK INCLUDED

A. Pipes, culverts and fittings, complete. Catch basins, drop inlets, manholes, end walls and other structures, complete as shown on drawings. Ditch protection and bracing requirements to conform to OSHA requirements and regulations. Piping and drains for sediment basins.

B. Related Work Described Elsewhere:

1. Site Preparation: Section 31 00 00
2. Earthwork: Section 31 20 00
3. Excavating, Backfilling and Compaction: Section 31 22 00
4. Erosion & Sediment Control: Section 31 25 00

PART 2  PRODUCTS

2.01  CONDUIT AND EMBEDMENT MATERIALS

A. Furnish fittings of same type and class of material as conduit.

B. Reinforced Concrete Pipe (RCP): ASTM C76, Class III. This pipe may be used in lieu of PVC.

C. Corrugated Metal Pipe (CMP): Helically corrugated 16 gauge galvanized metal uncoated, and conforming to AASHTO-M36. Pipe shall have rerolled ends.


E. Corrugated Polyethylene Pipe: High density polyethylene, corrugated exterior/smooth interior, 12 inch to 36 inch diameters conforming to AASHTO M252 with the addition that the pipe have a smooth interior liner. Material conform to ASTM D3350. Pipe equal to Hi-Q pipe as manufactured by Hancor, Inc.

F. Contractor has the option of using reinforced concrete pipe, polyvinyl chloride pipe or corrugated polyethylene for storm drainage except where pipe is encased in concrete. Do not substitute corrugated metal pipe for any of the above mentioned pipe.

G. Crushed Stone Pipe Bedding Materials: Size #7 or #8.
2.02 CONCRETE MATERIALS

A. Concrete Base: Pre-Cast or Cast-In-Place concrete, at Contractor’s option. Use concrete which will attain a 28-day compressive strength of not less than 3,000 psi.

B. Pre-Cast Concrete Structures: ASTM C478, sizes as indicated, eccentric cone pre-cast top, unless otherwise indicated. Pipe openings of proper size shall be carefully and accurately cut in or cast in.

2.03 MASONRY MATERIALS

A. Manhole and Catch Basin Brick: ASTM C32, Grade MS.

B. Sewer Brick: ASTM C32, Grade SS.

C. Masonry Mortar: ASTM C270, Type M. For minor amounts, use packaged materials complying with ASTM C387, Type M.

2.04 METAL ACCESSORIES

A. Manhole Frames and Covers: Grey cast-iron, ASTM A48, Class 30B. Comply with requirements of TDOT for type and style unless otherwise indicated, and equal to J.R. Hoe & Sons, Middlesboro, KY, #MC-325.

B. Catch Basin Frames and Gratings: Grey cast iron, ASTM A48, Class 30 or better. Comply with requirements of TDOT for type and style unless otherwise indicated, and equal to J.R. Hoe and Sons.

C. Curb Inlet and Gratings: Comply with requirements of TDOT for type and style unless otherwise indicated, and equal to J.R. Hoe & Sons.

2.05 EROSION CONTROL STONE

A. Rip Rap: Refer to Section 31 25 00, Erosion Control.

2.06 SUB-DRAIN MATERIALS

A. Polyethylene perforated tubing and fittings shall conform to SCS National Engineering Standard, Code 606, as manufactured by Hancor, Inc., or equal.

B. ASTM F405 or F667, AASHTO M252 or M294, and SCS 606.

C. Filter Stone: Open graded, washed stone such as ASTM No. 57.

D. Filter Sand: Clean concrete sand.

E. Filter Fabric: “Typar”.
2.07 DOWNSPOUT BOOTS

A. Downspout boots to be McKinley Standard Cast Iron with one coat of rust inhibitive primer, Type D54. Provide sizes to accommodate downspouts.

PART 3 EXECUTION

3.01 INSPECTION

A. Installer must examine areas and conditions under which storm sewer system work is to be installed and notify Contractor in writing of conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.

3.02 DRAINAGE STRUCTURES

A. Install at locations indicated and to required elevations. Set rectangular frames square with the nearest wall, building or pavement.

B. Where an inlet is part of the temporary erosion and sediment control measures, leave structure top below grade or leave temporary opening in side to collect water from silt basin sump. Complete installation after basin is no longer required.

3.03 TRENCHING

A. General:

1. Perform all trenching required for the installation of items where the trenching is not specifically described in other sections of these specifications.

2. Make all trenches open vertical construction with sufficient width to provide free working space at both sides of the trench and around the installed item as required for caulking, joining, backfilling, and compacting.

B. Depth: Trench as required to provide the elevations shown on the drawings. Where elevations are not shown on the drawings, trench to sufficient depth to give a minimum of 18" inches of fill above the top of the pipe, measured from the adjacent finished grade.

C. Correction of Faulty Grades: Where trench excavation is inadvertently carried below proper elevations, backfill with material approved by the Designer, and then compact to provide a firm and unyielding subgrade and/or foundation to the approval of the Designer and at no additional cost to the Owner.
D. Trench Bracing:

1. Properly support all trenches in strict accordance with all pertinent rules and regulations including current OSHA excavation and trench safety standards. The existing soil on the site should be classified as a Class C soil type.

2. Brace, sheet, and support trench walls in such a manner that they will be safe and that the ground alongside the excavation will not slide or settle, and that all existing improvements of every kind, whether on public or private property, will be fully protected from damage.

3. In the event of damage to such improvements, immediately make all repairs and replacements necessary to the approval of the Designer and at no additional cost to the Owner.

4. Arrange bracing, sheeting, and shoring so as to not place stress on any portion of the completed work until the general construction thereof has proceeded far enough to provide sufficient strength.

E. Removal of Trench Bracing: Exercise care in the drawing and removal of sheeting, shoring, bracing, and timbering to prevent collapse and caving of the excavation faces being supported.

F. Grading and Stockpiling Trenched Material: Control the stockpiling of trenched material in a manner to prevent water running into the excavations. Do not obstruct surface drainage, but provide means whereby storm and waste waters are diverted into existing gutters, other surface drains, or temporary drains.

G. Foundation for Pipes:

1. General: Grade the trench bottoms to provide a smooth, firm, and stable foundation free from rock points throughout the length of the pipe.

2. Foundation Material: Place a minimum of six (6") inches of the specified cohesionless material in the bottom of the trench.

3. Subsurface Conditions: In areas where soft, unstable materials are encountered at the surface upon which cohesionless material is to be placed, remove the unstable material and replace it with material approved by the Designer. Make sufficient depth to develop a firm foundation for the item being installed.

4. If the need for such over excavation has been occasioned by an act or failure to act on the part of the Contractor, make the over excavation and replacement at no additional cost to the Owner.

5. Shaping: At each joint in pipe, recess the bottom of the trench as required.
into the firm foundation in such a manner as to relieve the bell of the pipe of all load and to ensure continuous bearing of the pipe barrel on the firm foundation.

6. Accurately shape all pipe subgrade and fit the bottom of the trench to the pipe shape. Use a drag template shaped to conform to the outer surface of the pipe if other methods do not produce satisfactory results.

H. Bedding for Pipes:

1. General: Place the specified cohesionless material in the trench, simultaneously on each side of the pipe for the full width of the trench, to a maximum depth of three feet and a minimum depth of one foot above the outside diameter of the pipe barrel.

2. Densification: Densify the bedding material after placing by slicing with a shovel.

3. Take special care to provide firm bedding support on the underside of the pipe and fittings for the full length of the pipe.

I. Backfill for Pipes:

1. Using On Site Materials: After the pipe has been thoroughly bedded and covered, spread the on site material in uniform lifts of not more than eight (8") inches in uncompacted thickness, and then compact as specified in this section. Repeat the spreading and compacting procedure until adjacent grade level is attained.

3.04 INSTALLATION OF PIPE

A. General: Install pipe in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated. Inspect pipe before installation to detect any apparent defects. Mark defective materials with paint and promptly remove them from the site.

B. Lay pipe beginning at the low point of a system, true to the grades and alignment indicated with unbroken continuity of invert. Place bell ends or groove ends of pipe facing upstream. Install gaskets in accordance with manufacturer's recommendations for the use of lubricants, cements and other special installation requirements.

C. Installation by Type of Pipe:

1. Concrete Pipe: Install in accordance with applicable provisions of the American Concrete Pipe Association "Concrete Pipe Field Manual", unless otherwise indicated.

2. Plastic Pipe & Corrugated Polyethylene Pipe: ASTM D2321-89, with
compacted stone aggregate bedding, and in accordance with pipe manufacturer's written instructions.

3. Refer to drawings for backfill and bedding requirements.

3.05 CLEANING PIPE

A. Clear the interior of pipe of dirt and other superfluous material as the work progresses. Maintain a swab or drag in the line and pull past each joint as it is completed. Flush lines between structures to remove collected debris. Place plugs in the ends of uncompleted pipe at the end of the work day.

3.06 INTERIOR INSPECTION

A. Inspect pipe to determine if line displacement or other damage has occurred. Inspect lines between manholes or structures after approximately two feet of backfill is in place, and again at completion of the project. If the inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, correct such defects.

3.07 STRUCTURES

A. Masonry Construction (Contractor's option in lieu of concrete unless otherwise indicated):

1. Use sewer brick to construct masonry manholes. Mix mortar with only enough water for workability. Retempering of mortar will not be permitted. Keep mortar mixing and conveying equipment clean. Do not deposit mortar upon, or permit contact with, ground.

2. Lay masonry in mortar so as to form full bed with ends and side joints in one operation, and with full bed and vertical joints, not more than 5/8 inch wide. Protect fresh masonry from freezing and from too rapid drying. Where structures occur, set tops of frames and covers flush with finish surface.

B. Pre-Cast Concrete Construction (Contractor's option in lieu of masonry, unless otherwise indicated):

1. Place pre-cast concrete sections as shown on the drawings. Where manholes, set tops of frames and covers flush with finish surface. Use epoxy bonding compound where manhole steps are mortared into manhole walls. Provide rubber joint gasket complying with ASTM C433 or apply bituminous mastic sealant at joints of sections.

C. Poured In Place Concrete: In accordance with Division 03.

3.08 EROSION CONTROL STONE

A. Install filter cloth then hand place rip rap as indicated.
3.09 TESTING

A. Perform testing of completed conduits and structures in accordance with local authorities having jurisdiction and the Designer. Correct unsatisfactory conditions.

END OF SECTION