CJMW ARCHITECTURE

PROJECT MANUAL

Museum of the Marine

Jacksonville
North Carolina

Commission No. 06.0070

Volume 2

Museum of the MARINE
Community • Corps • Carolinas

30 December 2011

DOCUMENT 00 01 10 - TABLE OF CONTENTS

END OF DOCUMENT

SECTION 21 00 00

FIRE-SUPPRESSION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install all work of this Section as shown on the drawings, as specified herein, and/or as required by job conditions.

B. Submit and secure approval for all shop drawings (including coordination drawings), calculations, system components, from the local AHJ and the Owner's insurance company, prior to the start of installation.

1.02 REFERENCES

A. The installation and equipment shall conform to: 2009 International Building Code; Unified Facilities Criteria UFC-1-200-01, General Building Requirements (16 August 2010); UFC-3-600-01, Fire Protection Engineering for Facilities (14 July 2009); and applicable reference standards cited therein, including NFPA 13-2007 and NFPA 20-2007.

B. Perform the work in accordance with the requirements of the Contract General Conditions, Section 230000 General Provisions, and with the provisions of all applicable codes and laws.

1.03 RELATED SECTIONS

A. Division 01 Sections “Construction Waste Management And Disposal”.

B. Division 01 Sections “Construction Indoor Air Quality (IAQ) Management.

1.04 DESCRIPTION

A. General Description.

1. Fire protection for the new building shall consist of a new fire pump assembly and new automatic sprinkler system.

2. The fire pump assembly shall be rated for 500 gpm and sized to supply the hydraulically most demanding sprinkler system plus hose allowance. The water supply for the fire pump shall be from connect to the street water main.

B. Major Components

1. One (1) fire pump assembly including power transfer switch and controller
2. One (1) pressure maintenance pump assembly including controller
3. One (1) riser check valve assembly
4. Two (2) 4" sprinkler zone control assemblies
5. One (1) 3" preaction valve assembly including release panel and wall mounted air compressor
6. One (1) wall mounted Fire Department Connection

C. Work Starts at.

1. Flanged 6" fire service line located in the Fire Pump Room, downstream of the 6" backflow preventer.

D. Additional Components and Work.

1. Complete galvanized test and drain system piped to discharge to the building exterior (or other location as approved by the Engineer and Architect).
2. Complete hanger and earthquake bracing assemblies. All hanger and bracing components shall be galvanized.
3. Two (2) electric bells. An interior bell to be located near riser check valve and an exterior electric bell located at the exterior of the Fire Service Room.
4. Alarm actuating devices including tamper switches and flow switches.
5. Required accessories, drains and test connections.
6. Rough cutting and patching.
7. Coordination of all fire protection wiring requirements with Division 26.

E. General Design:

1. All piping and sprinklers shall be of the concealed type in areas where ceilings exist. Exposed piping and sprinklers will be installed in areas without ceilings.
2. All fire protection work shall be coordinated with other trades, the building's architectural features and with the ceilings, soffits, and partitions. Special care should be taken in areas where sprinklers are centered in ceiling tiles or with other ceiling features.

3. Do not run exposed piping in front of windows and skylights. Keep all exposed piping as high as possible and as tight to walls and ceilings/decking as possible. Exposed piping and sprinklers shall be installed in coordination with the buildings structural and architectural features. Concealed piping should be elevated +/- 6" above the ceiling. Coordinate all piping with lights, diffusers, and all other equipment above the ceilings. Provide any additional piping, offsets, and hanger assemblies required to meet the aesthetic considerations of this project. Do not locate piping in areas where it would interfere with door swings or required head clearances or egress paths.
4. Provide all required drain and control valves. All valves shall be a maximum of 7'-0" above the finished floor unless noted otherwise.
5. Do not attach any hanger assemblies directly to the underside of any roof assemblies. When supporting fire protection piping and equipment at the underside of roof construction, use "unistrut" type supplemental steel to span adjacent roof structure and attach equipment hangers to the "unistrut".

F. Related work specified elsewhere.

1. Finished patching
2. Electrical wiring
3. Fire extinguishers
4. Painting of exposed fire protection piping located in public spaces

1.05 SUBMITTALS

A. Procedure.

1. Prepare and make the submissions listed below and in Section 230000.

B. Materials.

1. Pipe and fittings
2. Wall plates
3. Sleeves
4. Control valves
5. Check valves
6. Drain and auxiliary valves
7. Riser check valve assembly
8. Sprinkler zone control assemblies
9. Pre-action valve assembly including release panel and air compressor assembly
10. 2-Way Fire Department Connection
11. Electric bells
12. Supervisory tamper switches

13. Hanger and earthquake bracing assemblies
14. Valve tags, charts, pipe makers, and equipment signage including hydraulic summary placards for sprinklers systems
15. Fire stopping assemblies
16. Pressure gauges
17. Sprinklers, escutcheons, and head guards
18. Spare sprinkler cabinet
19. Fire Pump assembly including pump controller and power transfer switch
20. Pressure maintenance pump assembly including pump controller
21. 2-way fire pump test connection
22. Fire pump test connection valve storage cabinet

C. Shop Drawings.

1. Provide dimensional installation piping layout(s) coordinated with all trades. Include all sprinklers, piping, pipe sizes, fittings, drains and auxiliary drain, hangers and locations, valves with identification numbers, alarm equipment, and all other necessary information required for a complete shop drawing. Each drawing shall accurately list the size, type and schedule of all pipe and fittings used on the project.
2. Determine any deviations from the contract documents (drawings and specifications) and clearly indicate them on in writing at the time of Bid.
3. Submitted shop drawings shall be clear and legible. Minimum text size shall be 1/8". All sprinkler information must standout on the shop drawings (i.e., bold piping, etc. or lighter background). Reverse reading drawings are not acceptable. Do not draw piping intersecting with other piping that does not actually connect. Poor quality printings, reverse reading drawings and drawings with excessive unnecessary information (i.e., field fabrication notes, etc.) will not be reviewed and will be returned for resubmission. Shop drawing submittal shall include a minimum ¼" scale including sections views to provide a reasonable representation of the piping and component layout.
4. With initial drawing submittal, include a complete, schematic type, riser diagram indicating all system components, hydraulic reference points, and elevations at each floor. Diagram shall include all information from the water main connection up to and including each sprinkler control assembly, and pre-action valve assembly. Also include volume of pre-action system and the fill rate and pressure (start and stop) settings of the air compressors.
5. With initial drawing submittal, provide a full height building cross-section indicating floor elevations, types of construction, and locations of ceilings, walls/partitions, and sprinkler piping. Include a complete drawing index with each submittal and on the first drawing in the fire protection shop drawing set.

6. Provide a complete drawing index with each submittal and on the first drawing in the fire protection shop drawing set.
7. On projects where there are multiple drawings per floor, include a key plan for each drawing.
8. Include a site plan indicating the water main, test hydrants (i.e., gauged and flowing hydrants), and fire department connection.
9. Shop drawings must include a NICET Level III or Level IV certification number (or a PE stamp) as proof of design and/or review by said NICET/PE certified/registered person.

D. Hydraulic Calculations.

1. Each calculation shall contain a water summary sheet indicating pressure and flow required at the fire pump and the pressure available at the required flow. Each cover sheet shall also include the shop drawing number and floor/level associated with the remote area. This information shall be included on associated shop drawing(s).
2. Calculations are to be brought back to the water main. Calculations must print out results in a consecutive format representing actual flow direction. Calculations, which do not conform to this requirement.
3. Calculations shall include a 10 psig design margin between the required pressure and the available water supply pressure (at the required flow).
4. Hydraulic reference points shall be clearly indicated on drawings. Do not use "pipe numbers"; provide consecutively numbered reference points at all areas indicated on hydraulic calculations starting at the connection to the water main.
5. All sprinklers in the remote area must be flowed in the calculations (i.e., do not exclude sprinklers in small rooms, closets, etc). Do not include any unsprinklered spaces in the determining the square footage of the remote area.
6. The remote area must be the minimum square footage indicated in the Contract Drawings. A reduction in the remote area square footage is not permitted with the use of quick response sprinklers.
7. Grid calculations shall include "Peaking" process (per NFPA requirements) to ensure calculation of most remote area.
8. HYDRAULIC SUMMARY DATA MUST BE INCLUDED ON SHOP DRAWINGS. Summary data shall include: location, file number, density, remote area square footage, number of sprinkler heads flowing, flow & pressure required at municipal water main along South Street.
9. Provide a calculation indicating the required pressure at the FDC required to supply the greatest sprinkler and hose stream demand.

E. Procedures.

1. Field acceptance testing of fire pump assembly including controller and power transfer switch.

F. Samples.

1. Submit three (3) samples on each of the following items:
   a. Sprinklers including escutcheons and cover plates
   b. Sprinkler head guards

G. Closeout Documentation.

1. At completion of installation work, provide complete "As-Built" documentation including revised shop drawings and hydraulic calculations that have been updated to reflect any changes to the design to accommodate field conditions, and the Operations and Maintenance Manual.

H. Operating and Maintenance Manual.

1. Before requesting acceptance of work, furnish five (5) printed and bound sets of the Operations and Maintenance Manual.
2. Each Manual shall include:

   a. Title Page identifying the project name & location, and contractor’s emergency contact information
   b. Table of Contents with tabbed sections
   c. A section providing a brief description of systems and components, and basic operating features
   d. A section providing the Manufacturer's name, (include address and telephone number) model number, service manual, spare parts lists, wiring diagrams and descriptive literature for all components including the fire pump pressure maintenance pump, controllers and automatic transfer switch
   e. A section providing maintenance instructions, listing of possible breakdowns and repairs of major components
   f. A section providing instructions for start-up and operation of major components including a detailed and simplified one line color-coded flow and wiring diagrams, and copy of fire protection systems’ valve tag chart
   g. A section that includes all as-built shop drawing and hydraulic calculations
   h. A section that includes the following witnessed certificates:
      - Contractor's Material And Test Certificate for Above Ground Piping (NFPA 13-2007, Figure 24.1)
      - Contractor's Material And Test Certificate for Underground Piping (NFPA 13-2007, Figure 10.10.1)

- Certificates shall include all required signatures along with printed names and titles of all individuals conducting the tests and witnesses

i. A section that includes factory certified fire pump performance test curve and field acceptance testing of the fire pump assembly in accordance with NFPA 20

j. A section that includes a copies of required procedures and summary of results:
   - Field acceptance testing of fire pump including controller and automatic transfer switch

k. A section that includes a copy of the first year's required inspections, testing and maintenance contract and copy of NFPA 25-2008

l. A section that includes a CD of all approved fire protection as-built shop drawings and hydraulic calculations, both .pdf and .dwg file types

1.06 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping (except for piping directly supplying sprinklers for such room):

1. Prohibited, except as noted, in:

   a. Electric Rooms and Closets.
   b. Telephone Equipment Rooms and Closets.
   c. Elevator Machine Rooms.

2. Prohibited, except as noted, over or within 5 feet of:

   a. Transformers.
   b. Substations.
   c. Switchboards.
   d. Motor control centers.
   e. Standby power plant.
   f. Bus ducts.

3. When over or within 5 feet unavoidable, provide drip pans under piping over electrical equipment.

1.07 QUALITY ASSURANCE

A. Quality of Materials.

1. All equipment and materials to be UL listed. All equipment and materials shall also be and Factory Mutual approved (unless noted otherwise).
2. New, best of their respective kinds and free of defects.

3. Electrical equipment: Listed by Underwriters Laboratories or bearing their label.
4. Secure approval from Architect, Engineer and all authorities having jurisdiction for materials, equipment, and installation prior to installation.
5. Obtain fire pump, pressure maintenance pump, controllers and automatic transfer switch through one source from a single manufacturer for each type of equipment.

B. Warranty.

1. All fire protection work shall be free from defects in workmanship and materials for a period of one (1) year from date of final acceptance shall meet all local and state codes. The Sprinkler Contractor shall repair all defects, which develop or are discovered within this period, to the satisfaction of the Owner, at no additional cost.
2. Provide (as part of the contract) all inspections, testing and maintenance required for the one (1) year period following final acceptance. Required inspections, testing and maintenance shall be those defined in NFPA 25-2008.
3. Provide (as part of the contract) service agreement for fire pump, pressure maintenance pump, controllers and automatic transfer switch for the one (1) year period following final acceptance. As part of the agreement, manufacturer's authorized service representative shall provide complete system inspection twice a year including: check of proper pump sequencing and alarm activation with adjustments, as required; and review of instructions for operating personnel, if requested. Any required service work to be noted in a formal inspection report along with a detailed proposal for the repairs. The service representative shall provide for 24 hour emergency service.

1.08 BASE BID MANUFACTURERS

A. Base bid on materials or equipment specified by:

1. Name of manufacturer.
2. Brand or trade name.
3. Catalogue reference.

B. Where two or more manufacturers are named, choice optional with bidder.

C. Manufacturers other than specified will only be considered if:

1. Stated at time of bid.
2. Proposed substitutions are named and submission of equipment of manufacturers other than specified shall detail equality and difference, item by item.

3. Difference in base bid is indicated including changes in cost of all work affected thereby.

PART 2 - PRODUCTS

2.01 PIPE

A. Above Ground.

1. Schedule 40 except as noted, seamless or welded mild steel, ASTM A-135, A-795 or A-53 for size 1" and larger.
2. Schedule 10 steel pipe may be used for size 2½" through 6" if supported by water quality analysis. Analysis must consider both microbiological and galvanic corrosion. Evidence of either corrosion potential or past history of sprinkler system failure due to corrosion would prohibit the use of schedule 10 pipe.
   a. If permitted, use of schedule 10 pipe shall be limited to wet pipe systems applications.
3. Minimum Wall 0.188" may be used for size 8"
4. Galvanized pipe shall be used for test and drain piping, above ground piping between fire department connection and check valve, piping for auto-ball drip and for any above ground piping subject to alternate wetting and drying (e.g. pre-action system piping), and air supply piping.
   a. Grooved end connections shall have cut grooves
5. Provide chrome-plated pipe for any exposed test and drain piping at the building exterior.

B. Underground.

1. Ductile iron pipe, thickness class 52, AWWA C151, double cement lined in accordance with AWWA C104 and coated on exterior, along with rods and clamps, with coal tar enamel.
2. Provide push-on rubber gaskets and setscrew retaining glands for attachment to mechanical joint fittings

2.02 FITTINGS

A. Above Ground.

1. Cast iron threaded: Standard weight, ANSI B-16.4.
2. Cast iron flanged fittings and flanges: Standard weight, ANSI B-16.1.
3. Malleable iron: Threaded and banded, standard weights, ANSI B-16.3.
4. Steel welding: Standard seamless steel, ANSI B-16.9 and ASTM A-234.
5. Steel flanges: ANSI B-16.5, ASTM A-181 Grade 1 up to 300 PSI.

6. Grooved end ductile iron fittings, and bolted clamp type ductile iron couplings with rubber sealing gaskets for grooved end pipe, 250-PSI WWP. Allowed for size 1¼" and larger. Similar to: VICTAULIC Co.
7. Couplings for pre-action system shall employ “flush seal” type gaskets.
8. Plain end fittings and bushings are NOT PERMITTED.
9. All reducing fittings shall be tapered. Reducing couplings are allowed for one "nominal" pipe size reduction (i.e.: 6" x 4", 3" x 2 ½“, etc).
10. Galvanized fittings shall be used with galvanized pipe.
11. Provide chrome-plated fittings for any exposed test and drain fittings at the building exterior.

B. Underground.

1. Ductile iron, pressure class 250, AWWA C110 & C111, mechanical joint type, cement lined in accordance with AWWA C104 and coated on exterior, along with rods and clamps, with coal tar enamel.

2.03 WALL PLATES

A. Chrome plated, heavy gauge steel, hinged split ring wall plate with spring steel inserts and positive locking tab. For exposed piping through interior floors, walls, and ceilings. Similar to: ARGCO series.

B. Chrome plated, heavy duty, forged brass, one piece, wall plate with setscrew. For exposed piping through exterior walls. Similar to: ARGCO series.

2.04 SLEEVES

A. Install galvanized steel, schedule 40, pipe sleeves for pipes passing through floors, walls, and partitions. Sleeves shall be sized per NFPA requirements. Floor sleeves shall project 1” above finished floor to prevent seepage.

1. 16 gauge galvanized sheet metal sleeves may be used for pipes passing through partitions.

B. All sleeves passing through any rated construction shall be sealed with a UL listed fire and smoke resistive assembly

C. Grout-in all sleeves through concrete walls and floors.

D. All sleeves passing through exterior walls shall be schedule 40 galvanized steel pipe with integral water stop. Seal shall be interlocking expandable synthetic rubber links, assembled with corrosion resistant bolts, nuts, and pressure plates. Similar to: LINK-SEAL

2.05 VALVES

A. General.

1. Above ground valves shall be UL and FM approved. Similar to: KENNEDY, NIBCO, VICTAULIC or MILWAUKEE.

B. Above ground Valves.

1. 2" and smaller:

a. Butterfly type, slow close indicating valve with built-in tamper switch, threaded or grooved, 175 PSI. Similar to MILWAUKEE, Model No. BB-SCS02 OR BB-VSCS02 ("Butterball")
b. Gate type, OS&Y, bronze, threaded, 175 PSI WWP. Similar to: NIBCO, Model T-104-O.

2. 2 ½ " to 6":

a. Butterfly type, Tight closing, epoxy coated ductile iron, elastomer encapsulated disc, grooved, 300 PSI WWP, with stainless steel shaft, lifetime bearings, handwheel gear operator with position indicator, and built-in tamper switch. Similar to: VICTAULIC, Series 705W OR 705W RD ("FireLock")
b. Gate type, OS&Y, resilient wedge, flanged, 250 PSI WWP, pre-grooved stem for tamper switch, tapped and plugged boss. Similar to: NIBCO, Model F-607-RW.

C. Check valves.

1. 2" and smaller:

a. Swing type, bronze, threaded, rubber disc, 200 PSI WWP. Similar to: NIBCO, Model KT-403-W.

2. 2 ½" and larger:

a. Grooved, 250 PSI. Similar to: VICTAULIC, Series 717 ("FireLock").

D. Drain and Auxiliary Drain Valves.

1. Threaded bronze angle or globe type with composition disc, 175 PSI. Similar to: NIBCO KT-65, KT-211, KT-67, and KT-301.

2. Provide valves (not plugs) as required and at indicated locations for complete drainage of systems.
3. Pipe all drain and sprinkler test piping to the building exterior. Drains that drain to a floor drain, sump pit, or mop sink, will only be permitted with approval from the Engineer and Owner. Provide any required pipe, fittings, and labor to terminate drains at approved coordinated locations.
4. At system low points where drain piping does not extend to a drain receptacle, provide a threaded hose and adapter at the valve outlet (where permitted by the Engineer).

E. Automatic Ball Drip Valves.

1. ¾" bronze, threaded, angled. Similar to: POTTER-ROEMER Model 5984.
2. Pipe to an approved drain location.

2.06 SPECIALTY VALVES

A. Riser Check Valve Assembly

1. Grooved check valve including 2" main drain, and two pressure gauges each with a maintenance valve, and waterflow switch.
2. Waterflow switch shall actuate main fire alarm panel.
3. Similar to: VICTAULIC, Model 717R.

B. Sprinkler Control Assemblies.

1. Grooved manifold body, including a grooved control valve with tamper switch, waterflow switch, pressure gauge with maintenance valve, and a test & drain valve assembly.
2. Similar to: VICTAULIC Model 747M.

C. Double Interlocked Preaction Valve Assembly

1. The double interlocked preaction system shall be actuated by properly spaced smoke detectors (provided by Division 26) in conjunction with operation of an automatic sprinkler. The system shall monitor the piping for leaks or damage to a sprinkler (with pressurized air) to avoid accidental valve activation.
2. Grooved unit with alarm switches to actuate building fire alarm system and local electric alarm bell, high/low air supervisory switch, drains, gauges, test apparatus with required accessories, accelerator, anti-flooding device, pressure maintenance device with pressure switch, and water column kit. The dry pipe valve shall be a low differential, latch and actuator design that allows the valve to be reset without opening the valve. The low differential design shall not be subject to water columns. The valve shall have a low-

pressure actuator, which is pneumatically actuated and requires only 13 psi minimum air pressure, regardless of the system supply pressure. The actuator shall allow the system to operate with a low air or gas pressure of 7 psi.

3. The valve shall be made of high-strength, low-weight ductile iron, and have easy access to all internal parts. All internal parts shall be replaceable. Maintenance and service shall be possible without removing the valve from its installed position. The rubber clapper seal shall be easily replaceable without removing the clapper from the valve. The valve shall be painted inside and out to increase corrosion resistance. The valve body shall be tapped for main drain and all available trim configurations.
4. Body: Ductile iron conforming to ASTM A-536, grade 65-45-12. Clapper: Aluminum bronze UNS-C95500, Latch: Aluminum bronze UNS-C95500, Shaft: Stainless 17-4, Clapper Seal: Peroxide cured EPDM - ASTM D2000, Bushings/Seat O-rings: Nitrile, Springs: Stainless Steel (300 Series), Diaphragm: Peroxide cured EPDM with fabric reinforcement. Pre-action valve shall be UL listed and Factory Mutual approved.
5. Similar to: VICTAULIC, Series 769 FireLock NXT Preaction Valve, electric/pneumatic release trim. Release panel similar to: SYSTEM SENSOR, model PDRP-2001
6. All wiring between main fire alarm control panel and preaction valve assembly including wiring of the release panel shall be responsibility of Division 26.
7. Required air pressure for Series 769 Firelock NXT Preaction Valves is 13-psi minimum, regardless of the system supply water pressure. Air pressures must be kept at or below 18 psi.
8. Air Maintenance Compressor: Air Maintenance Compressor, wall mounted, 115 volt, single phase, electric motor-driven, air compressor package. Air compressor motor shall be minimum 1/3 horsepower in size and produce sufficient cfm to fill the pre-action sprinkler system in 30 minutes or less. Air compressor shall be set to maintain system pressure between 13-18 psig. The compressor assembly shall be fully automatic, direct drive, have an air intake filter, oil-less piston compressor, have a UL Listed pressure switch, bubble tight air check valve, with permanently lubricated bearings. The air compressor assembly shall be listed as an air maintenance device. Similar to: GENERAL AIR PRODUCTS, OL-LP (low pressure) series.
9. All wiring of the pre-action valve release panel and of the air compressor assembly shall be the responsibility of Division 26.

2.07 FIRE DEPARTMENT CONNECTIONS

A. 2-Way flush mount.

1. 2-Way, cast brass body with built-in drop clappers and top outlet, two 2½ hose thread inlets x 4" NPT outlet.

2. Hose thread type shall comply with local requirements.
3. Finish shall be polished chrome plated OR as otherwise specified by the Architect.
4. Similar to: POTTER-ROEMER, Model 5023
5. Provide cast brass, polished chrome plated identification base plate with words "AUTO. SPKR."
6. Provide written statement under company letterhead with material submittal that the submitted hose thread type and lettering has been confirmed with responding Fire Department.

2.08 PUMPING FACILITIES

A. Fire Pump Assembly.

1. Fire Pump

a. Pump shall be an electrical motor driven, horizontal split case single stage type.
b. Design capacity: 500 gpm at approximately 85 psi. Actual pressure rating shall be confirmed by contractor and based on current water flow test results and hydraulic calculations
c. Design attributes: 40 HP, 3525 RPM, 480 volt, 3 phase
d. Similar to: PEERLESS PUMP, Model 4AEF10G
e. Underwriters Listed and Factory Mutual Approved
f. The fire pump assembly shall be arranged to run continuously until shut down manually

2. Pump Accessories.

a. Suction and discharge fittings
b. Liquid filled discharge and suction pressure gauges
c. Automatic air release valve
d. Casing circulation relief valve
e. Pump test valve and flush mounted test header assembly
f. Digital pressure recorder device that includes monitoring of the voltage and amperage of the fire pump controller. Similar to FIRETROL “MARK II”

3. Motor.

a. Delta-wound squirrel cage motor with all leads brought out of the motor terminal box
b. Grease lubricated radial bearings and oil lubricated thrust ball bearings carrying total thrust of entire pump assembly
c. Vertically mounted
d. Drip-proof with drip cover

4. Fire Pump Controller.

    a. Soft-start, soft-stop, interrupting transfer switch, and suitable for use as Service Equipment.
    b. Isolating disconnect switch / circuit breaker, sized to coordinate with specified motor and controller.
    c. Fire pump isolating disconnect switch shall be lockable in the on and off positions with 2 sets of normally open and normally closed Form C contacts rated 4 amperes @ 30 volts DC. Provide connections for switch, open or tripped, to signal a trouble alarm at the fire alarm control panel, to interrupt the fire pump PTS emergency generator start circuit, and to provide a status signal to the BMS Floor mounted and enclosed, with required accessories including power failure alarm, phase reversal alarm, and pump running alarm.
    d. Contacts shall be wired to terminal block for extension to building fire alarm system.
    e. Similar to: FIRETROL, Model FTA1930.

5. Power Transfer Switch.

    a. A power transfer switch shall be provided in accordance with NFPA 20, Article 7.8. The same manufacturer as the fire pump controller shall construct the PTS, which shall be UL listed/F.M. approved for fire pump service.
    b. The ATS shall be housed in a dedicated NEMA 2 enclosure (attached to the fire pump controller) and labeled "Automatic Transfer Switch -Fire Pump".
    c. A complete wiring diagram shall be provided for field wiring to the emergency power source and the electric fire pump controller.
    d. The PTS shall be rated for 125 amps, 208 volt, 3 phase, withstand current rating (WCR) - 200,000 amps RMS SYM.
    e. Engine control contacts, both N.O. and N.C., shall be provided to start the generator set when the normal power source fails. These contacts shall be designed for low voltage start signals.
    f. Similar to: FIRETROL model FTA950

B. Pressure Maintenance Pump Assembly.

1. Multi-stage, in-line type
2. Design capacity: 10 GPM, +/-85 PSI head,
3. Design attributes: 3500 RPM, 1.5 HP, 208 volt, 3 phase, 1-1/4" suction, 1-1/4" discharge connections.
4. Similar to GRUNDFOS PUMPS CORP, model CR3-7

C. Pump Accessories.

1. Tamper switches - Provide tamper switches on the pressure maintenance pump suction and discharge control valves.

D. Motor.

1. Squirrel cage induction type, grease lubricated, vertically mounted, drip proof with drip cover.

E. Pressure Maintenance Pump Controller.

1. Wall mounted and enclosed with required accessories.
2. Running period timer.
3. Similar to FIRETROL model FTA500

2.09 FIRE PUMP TEST MANIFOLD

A. 2-Way flush mount.

1. 2-Way, cast brass body with angle inlet, two (2) 2½" connections outlets with hose thread, two (2) caps and chains x 4" NPT inlet.
2. Hose thread type shall comply with local requirements.
3. Finish shall be rough chrome plated body with polished chrome plated trim OR as otherwise specified by the Architect.
4. Similar to: POTTER-ROEMER, Model 5862
5. Provide cast brass, polished chrome plated identification base plate with words "FIRE PUMP TEST"
6. Provide two (2) 2½" gate valves, brass body with brass trim and swivel inlet. Similar to POTTER-ROEMER, Model 4365.
7. Provide written statement under company letterhead with material submittal that the submitted hose thread type and lettering has been confirmed with responding Fire Department.

2.10 ALARM ACTUATING DEVICES (Coordinate with Division 26)

A. Closed circuit OS&Y type valve tamper switches to operate within two revolutions of valve wheel.

1. Built-in models or Similar to: POTTER Electric Signal Co. model OSYSU-2.

B. Closed circuit Ball type valve tamper switches to monitor full open position of ball valve.

1. Built-in models or Similar to: POTTER Electric Signal Co. model RBVS.

C. Closed circuit waterflow indicators with retarding device to prevent false alarms from line surges.1

1. ½" and smaller:

a. Similar to POTTER Electric Signal, Model VSR-S

2. 2” and larger:

a. Similar to: POTTER Electric Signal, Model VSR-FE-2

D. All wiring from devices to main fire alarm panel to be responsibility of Division 26.

2.11 ALARM INDICATING DEVICES (Coordinate with Division 26)

A. Electric Bell.

1. 6" diameter Underwriters listed 24-volt DC type. Include weatherproof box and seal. Provide one electric bell inside the fire protection room and one on the building exterior. Coordinate exterior location with Architect.
2. Similar to: POTTER ELECTRIC SIGNAL CO. Model PBD246.

B. All wiring from devices to main fire alarm panel to be responsibility of Division 26.

2.12 VALVE TAGS, CHARTS, PIPE MARKERS AND EQUIPMENT SIGNAGE

A. Tags.

1. Brass 18 gauge with ½" stamped numbers and ¼" letters filled with black paint. Not less than 1 ½" inches round with 3/16" top hole.

a. Similar to: SETON Style No. 65542.

2. Provide on all valves and controls identifying numbered metal tags, with letter to indicate system (FP) fastened by heavy brass hook and chain.

a. Similar to: SETON Style Nos. 16197 and 16182.

B. Charts.

1. Provide (two) frame mounted and laminated: Valve tag charts along with a diagrammatic/schematic diagram showing essential features of system.
2. All fire protection control, test and drain valves shall be tagged.
3. Valve numbering and lettering shall correspond to designation on the metal valve tags.
4. Valve tag chart shall indicate valve location, function, and area controlled. Minimum size is 11" x 17".

C. Markers.

1. Provide ½" wide self-adhesive pipe markers with flow arrows at reasonable locations (not to exceed 30' intervals) and in accordance with Section 15000, on all concealed and exposed piping.

a. Similar to: SETON brand style Nos. M4268 and M4167.

D. Signage.

1. Provide proper signage on all fire protection valves and devices, describing device and function in accordance with NFPA requirements.

2.13 PIPE HANGERS and EARTHQUAKE BRACING

A. Top Beam Clamps.

1. Carbon steel, galvanized, clamp body with hardened steel cup point setscrew and locknut. Body shall be tapped through to permit extended adjustment of threaded rod. Similar to: TOLCO Figures 65 and 66.
2. Provide retaining straps for all beam clamps.

B. Hanger Rods.

1. Carbon steel, galvanized, continuous thread sized in accordance with NFPA 13 requirements. Similar to: TOLCO Figure 99.
2. Do not bend hanger rods. Use appropriate offsetting brackets/clamps.

C. Swivel Rings.

1. Carbon steel, galvanized. (For sizes 1" and larger). Similar to: TOLCO Figure 2.

D. Expansion Anchors.

1. Maximum loading, including pipe contents, covering and all required loads shall be 75 percent of rated load, SAE 110M, slotted type, plated with dull zinc finish. Similar to: HILTI Drop-In Anchor (HDI).
2. Use only at Owner approved locations.

E. Side Beam Brackets.

1. Carbon steel, galvanized, flush back plate with threaded eye socket, for pipe sizes 1" through 4".
2. Similar to: TOLCO Fig. 57.

F. Split Ring Hangers.

1. Carbon steel, galvanized, split ring hanger.
2. Similar to: ERICO, Model NI 429.

G. Steel Rod Couplings.

1. Carbon steel, galvanized
2. Similar to: TOLCO Fig. 70.

H. Earthquake Bracking.

1. Carbon steel, galvanized, UL/FM approved. Similar to: TOLCO Figures 906, 907, 908, 909, 910, 975, and 1000.

I. Other Hanger Materials.

1. All other hanger materials, assemblies and methods shall be UL/FM approved for their intended application.
2. All hanger and bracing material must be galvanized.

2.14 PRESSURE GAUGES

A. 3½” diameter, single spring, bronze bourdon tube with brass case and chrome plated brass ring with heavy glass. Include a shutoff/bleeder valve for testing and replacement.

1. Provide a pressure gauge with valve at the top of all risers.

2.15 SPRINKLERS

A. General.

1. Cast brass, closed, quick response bulb type, standard spray with ½" discharge orifice.
2. Include complete sprinkler head descriptions on shop drawings. Provide make, model, temperature rating, and Sprinkler Identification Number (SIN) for all sprinklers.
3. Similar to: VIKING Corp. models unless noted otherwise.
4. Utilize ordinary temperature ratings, except as noted. Utilize high temperature ratings where subject to abnormal heating and conditions such as near heaters, heating lines, and in blast of heaters.
5. On exposed piping, use upright heads wherever possible and pendent type where necessary.
6. All sprinkler heads shall be quick response type (unless noted otherwise).

B. Sprinkler Types.

1. Exposed upright or pendent type, ½", brass. Similar to: VIKING Corp., SIN VK300 and VK302. Architect shall select finish.
2. Horizontal sidewall type, ½", brass. Similar to: VIKING Corp., SIN VK305. Architect shall select finish and style.
3. Extended coverage horizontal sidewall type, ¾" brass, 8.0 K-Factor. Similar to VIKING Corp., SIN VK630. Architect shall select finish.
4. Concealed pendent type, ½", brass, adjustable, with cover plate. Similar to: VIKING Corp., SIN 462. Architect shall select finish.
5. Dry horizontal sidewall type, ½", brass, adjustable with escutcheon plate. Similar to: VIKING Corp., SIN VK156. Architect shall select finish.
6. Extended coverage horizontal sidewall type, ¾", brass, 8.0 K-Factor, recessed with thread-on recessed escutcheon. Similar to: VIKING Corp., SIN VK630. Architect shall select finish.

C. Accessories.

1. Escutcheons shall be listed for the specific sprinklers they are used with. Similar to VIKING Corp., Model E-2.
2. Sprinkler head guards shall be listed for specific sprinkler heads they are protecting. Similar to VIKING Corp., Model D-1.

2.16 CABINETS

A. Spare Sprinkler Cabinet.

1. Enameled red steel. Similar to: POTTER-ROEMER, Model 6162.

2. Equipped with a minimum of two (2) sprinklers of each type and temperature rating used on the project, but not less than twelve (12) sprinklers. Concealed covers shall be provided when required by sprinkler type.
3. Equipped with a sprinkler wrench(s) that is needed to remove and install the types of sprinklers included in the cabinet.
4. Equipped with a list of each type and temperature rating of sprinklers used on the project.

B. Fire Pump Test Connection Valve Storage Cabinet

1. Cabinet shall be sized to accommodate the three (3) fire pump test connection valves. Approximate size will be 20” wide x 20” high x 9.25” deep.
2. Cabinet construction shall be of 20-gauge sheet metal box, with a 20-gauge tubular steel door and 18-gauge frame.
3. Cabinet shall be surface mounted.
4. Door style shall be flush solid metal door with lock.
5. Finish shall be powder-coated with an electrostatically applied, thermally fused, recoatable OSHA red finish.
6. Labeling shall be: "FIRE PUMP TEST CONNECTION VALVES"
7. Similar to POTTER-ROEMER, Model 1815.

2.17 FIRE STOPPING

A. All fire stopping shall be UL listed assemblies.

1. Similar to: HILTI Firestop Systems.

PART 3 - EXECUTION

3.01 PIPING – GENERAL

A. Approximately as indicated, modify to suit building conditions, avoid interferences with other trades and maintain pitch.

B. Provide additional offsets, fittings, valves, drains, etc., where required by construction and work of other trades.

C. Run in chases, recesses, shafts, hung ceilings and beam cuts where applicable. Do not cover before examination and testing.

1. Run parallel with or at right angles to walls, other piping, neatly spaced with plumb risers.
2. Maintain 1” clearance between hubs, coverings and adjoining work.

D. Provide reducing fittings for changes in pipe size.

1. No bushings or street elbows permitted.
2. Grooved reducing couplings are acceptable for decreases of one nominal pipe size. (I.e.: 6" x 4", 3" x 2 ½", etc.).

E. Concealed piping in hung ceilings.

1. Obtain ceiling heights from Architect's Drawings.

F. Use extra heavy pipe for nipples where unthreaded portion of pipe is less than 1 1/2 inches long. No close nipples permitted.

G. Joints.

1. In accordance with manufacturer's instructions.
2. Provide dielectric fittings wherever pipes of dissimilar materials are connected.
3. Screwed piping: Clean-cut of exact length, ream pipe after cutting and threading, apply approved compound on male threads only, apply graphite on drain plugs.
4. Use extra heavy pipe for nipples where unthreaded portion of pipe is less than ½ inches long. Use close nipples only where necessary.
5. Ductile iron bell and spigot piping.

    a. Push-on rubber gasket joints, ANSI A21.11.
    b. Mechanical stuffing box type: Bolted assembly, ANSI A21.11.

6. Underground piping:

    a. Reinforce joints at fittings and valves with galvanized steel clamps and 3/4 in. galvanized steel rods, approved masonry thrust blocks in accordance with manufacturer's recommendations or combination of both in accordance with NFPA 13 and manufacturer’s recommendations.
    b. Paint clamps and rods with heavy coat of bitumen solution paint.

H. Mechanical outlet fittings.

1. Must be equal to VICTAULIC #920 for sizes available, and #920N, where a #920 is not available in the required size. No other types or styles will be permitted.

I. Flanged piping with full-faced rubber gaskets.

J. Welded piping: (Shop application only, NO FIELD WELDING)

1. Oxyacetylene or electric arc process in accordance with latest accepted practice and in accordance with Underwriters Laboratories.
2. Performed only by welders meeting qualifying tests for strength welds in pressure piping of ANSI.
3. Provide, have tested, and submit for review, standard sample welds for each welder before he commences work.
4. Remove foreign matter from ends of pipe before tacking and welding, align pipe ends concentric, then tack weld to prevent misalignment during welding.
5. Welding fittings.

    a. Factory made, forged steel.
    b. Fabricated: Not permitted.

6. Connections.

    a. One-half size of main or smaller, Weld-o-lets or Thread-o-lets permitted.
    b. Larger connections: Regular welding tees.
    c. Hammer, clean and flush out piping after welding to remove scale, slag, welding beads, etc.

3.02 CONCRETE BASES

A. Provide reinforced concrete bases of sufficient dimension for fire pumps, pressure-maintenance pumps, and controllers.

3.03 SLEEVES

A. Provide required clearance between piping and sleeves as required by NFPA 13.

B. Provide reduced clearances and flexible couplings wherever possible and increased clearances where necessary, unless noted otherwise.

3.04 PIPING SUPPORT

A. Maximum loading, including pipe contents, covering and all required loads, 75% of rating.

1. Support piping so as to secure in place, maintain required pitch and prevent vibration.

2. Design and installation shall be in accordance with NFPA 13.
3. Provide for expansion and contraction.
4. No piping shall be hung from other piping, ductwork, conduit, ceiling structure, etc.

B. Suspended Horizontal Piping:

1. Chain, strap, perforated bar and wire hangers: NOT PERMITTED.
2. Suspension from inserts, beam clamps, steel fishplates, cantilever brackets, or other approved methods with threaded rods with double nuts tightly made up.
3. Where overhead construction does not permit fastening hanger rods in required locations, provide additional steel framing as required and reviewed.
4. Maximum hanger spacing per NFPA 13 requirements.

C. Vertical Piping.

1. Riser clamps, bolted on each side of pipe and bearing equally on structure.
2. Similar to: TOLCO Riser Clamp Fig. 6.
3. Minimum clamp spacing: At every floor (or at a maximum of 15' on center).
4. At offset from vertical: By hanger on horizontal branch close to riser or base fitting on foundation.

D. If removal of existing fireproofing is required for installation purposes, such removal shall be kept to a minimum. The Fire Proofing Contractor shall replace all removed fireproofing with new, to the satisfaction of the Owner at no additional cost to the owner.

E. The Contractor shall provide all supplementary structural steel required or spanning between, or connecting to, building structural members, for the hanging or support of piping. Welding to or drilling into building structural members will not be permitted without the approval of the Owner and the Structural Engineer.

F. Supports: Hang or support sprinkler piping from overhead construction in accordance with NFPA 13, and maintain maximum headroom as practical.

G. Underground Piping: All underground piping shall be laid on 6" sand and backfilled with clean fine earth compacted to 12" above pipe. Complete backfill with available earth free of large boulders and sharp rocks. Tamp and overfill to allow for settlement.

3.05 CLEANING AND ADJUSTING

A. Brush and clean work, prior to concealing, painting, and acceptance. Perform in stages, if directed.

B. Painted or exposed work that is soiled or damaged must be cleaned and repaired to match adjoining work before final acceptance.

C. Remove debris from the inside and outside of all material and equipment.

D. Flush piping at least twice after installation and before final connections are made in a manner as directed and/or approved by the Owner, and in accordance with NFPA 13 requirements. Make all temporary connections and furnish all appliances required for the purpose of proper flushing at no extra expense to the Owner.

E. Adjust alarm-indicating devices to meet the requirements of the NYC Fire Marshal.

F. Remove and properly dispose of all unused or waste material.

3.06 TESTS

A. Provide required labor, equipment and connections for the following tests of the Combined Standpipe and Sprinkler System.

1. Pressure Test – The entire system shall be subjected to a hydrostatic test pressure of two hundred twenty five (225) psig for two (2) hours in accordance with NFPA 13.
2. Air Test – The pre-action system shall be subjected to an air test pressure of forty (40) psig for 24 hours in accordance with NFPA 13
3. Trip Test – The pre-action system shall be subjected to a timed trip test in accordance with NFPA 13
4. Fire pump assembly acceptance testing in accordance with NFPA 20
5. Repair or replace defective work as indicated or as directed at no extra cost to the Owner.
6. Submit results of all testing for review within 1 week of completion of the test. Also include the results of all testing in O&M manuals.
7. Pay for cleanup and restoration or replacement of damaged work of others due to testing (which section 210000 may be responsible for)

B. Engage a factory-authorized service representative to review field-assembled fire pump assembly including fire pump, pressure maintenance pump, controllers and automatic transfer switch, all connections, and to observe and assist with acceptance testing. Results of all observations shall be reported in writing. Representative shall also train Owner's maintenance personnel on how to adjust,

operate, and maintain fire pump, pressure maintenance pump, controllers, and automatic transfer switch.

3.07 VALVES

A. Provide control valves where indicated in the contract drawings or required. All valves shall be accessible.

B. Seal valves in proper position and provide approved tag and/or signage indicating purpose of valve. Indicate accurate field pressure settings of any pressure-activated valves.

1. Provide control valves with 24 volt closed circuit supervisory tamper switches, (see Alarm Actuating Devices section of this specification), mounted in accordance with manufacturer's requirements.
2. Install all valves at a maximum of 7'-0" above the finished floor unless otherwise indicated on contract drawings.

3.08 SPRINKLERS

A. All sprinklers shall be used in accordance with all conditions, requirements, and limitations of their listing and in accordance with NFPA 13 and all other applicable codes.

B. Install sprinklers, in hung ceiling areas, center of tile OR wood panels and align heads symmetrically with ceiling tile or panel. Install sprinklers in gypsum and plaster ceilings symmetrically and align with adjacent ceiling fixtures.

C. Install all concealed sprinklers on return bends.

D. Provide factory applied custom finishes and colors as selected by the Architect.

E. Refer to Architectural ceiling plans for preferred locations of sprinklers. Refer to architectural sections and details for required pipe routing. Notify Architect and/or Engineer of any conflicts.

3.09 WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess materials are Contractor's property. At completion of work, remove from Project site.

B. Excess Waste: Disposal and recycling of waste shall comply with requirements of Division 01 Section “Construction Waste Management And Disposal”. Provide documentation of compliance.”

END OF SECTION 21 00 00

SECTION 220000

PLUMBING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment and services necessary to furnish, deliver and install all work of this Section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of the Contract General Conditions, Section 230000 General Provisions, and with the provisions of all applicable Local, State, and Federal Codes and laws.

1.03 SCOPE OF WORK

A. The work under this Section shall include all incidentals, labor, material, equipment, appliances, services, hoisting, scaffolding, supports, tools, consumable items, fees, licenses, and administrative tasks required to complete and make operable the plumbing work shown on the drawings and specified herein.

B. The Contractor shall furnish and install all equipment as necessary to provide a complete installation including system check out and start up on each item and system. The following equipment shall be provided:

1. Sanitary, waste, and vent systems.
2. Building sanitary drain to 5'-0" outside building.
3. Storm and roof drainage systems.
4. Building storm drain to 5'-0" outside building.
5. Domestic hot and cold water systems.
6. Domestic water service to street main.
7. Fire protection water service.
8. Fuel gas systems.
9. Kitchen equipment plumbing support systems and connections.
10. Pipe materials
11. Pipe hangers and supports
12. Insulation
13. Valves
14. Pressure regulating valves
15. Cross connection protection devices.

16. Pipe sleeves and seals.
17. Drains
18. Cleanouts
19. Plumbing fixtures
20. Water heating equipment
21. Pumps
22. Domestic booster pumping systems.
23. Water detection systems.
24. Hose bibbs and wall hydrants.
25. Drip pans.
26. Access panels.
27. Trap primers.
28. Miscellaneous plumbing specialties.

1.04 WORK BY OTHERS

A. Division 26 shall provide power wiring to electrical devices. Section 220000 shall provide and install all control wiring required for equipment operation. Section 220000 shall provide motor starters for installation by Division 26.

B. Section 220000 shall provide and install all make- up water distribution to HVAC equipment from outlet valve of backflow preventer. Section 220000 shall provide and install backflow preventer.

C. Section 203523 shall provide and install indirect condensate waste piping and trap to drain receptor from all HVAC equipment.

D. Excavating, backfilling, and compacting shall be provided under other divisions of this specification. Coordinate requirements.

E. Concrete housekeeping pads for floor-mounted equipment and concrete pits shall be provided under other divisions. Coordinate exact locations, dimensions, piping locations, and anchor bolt requirements.

1.05 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to all State, Local, and Federal Codes and Laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers shall be considered, subject to its acceptability in the Engineer's judgment and opinion. The equipment must conform to the operational characteristics and dimensions established by specified item and the drawings for mechanical spaces and other clearances.

C. The following manufacturers, vendors or materials, when provided in accordance with requirements of this Division, are approved for use. Materials supplied shall comply with specification requirements and be of a product of approved manufacturers. No deviations from this list shall be permitted unless specifically approved, in writing, after submission of satisfactory evidence relative to compliance with specification requirements.

1.06 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000.

B. Shop Drawings: Submit shop drawings of all items proposed to be furnished and installed under this Section which shall include but not be limited to.

1. Coordination drawings, coordinated with all other trades as outlined in Section 230000.
2. Piping materials, joints and fittings.
3. Valves, tags and name plates with schedule and location.
4. Pipe hangers and supports
5. Insulation
6. Valves
7. Pressure regulating valves
8. Cross connection protection devices.
9. Pipe sleeves and seals.
10. Drains
11. Cleanouts
12. Plumbing fixtures
13. Water heating equipment
14. Pumps
15. Water detection equipment.
16. House tank equipment.
17. Hose bibbs and wall hydrants.
18. Drip details.
19. Access panels.
20. Trap primers.
21. Miscellaneous plumbing specialties.
22. Welding certifications: submit reports as required for piping work,
23. Brazing certifications: submit reports as required for piping work.
24. Manufacturers' recommended installation procedures which, when approved, will become the basis for inspecting and accepting or rejecting actual installation procedures used on the work.

PART 2 - PRODUCTS

2.01 PIPE MATERIALS

A. Sanitary, waste, vent, and storm piping above ground (up to and including 10" size) within building: Hubless cast iron pipe with no hub fittings CISPI 301 and "Clamp-All 125" or 4 band "Huskey" clamps.

B. Sanitary, waste, vent, and storm piping below ground (all sizes and above slab over 10" size) within building: service weight cast iron pipe and fittings with hub and spigot ends, ASTM A74. Seal: one-piece neoprene rubber gaskets matching the internal configuration of the hub.

C. Exterior sanitary sewer pipe and fittings below ground (up to and including 12" size): polyvinyl chloride (PVC) type SDR35 pipe and fittings, ASTM D2665; D2949; D3034; F891. Pipe shall be installed in accordance with ASTM D2321.

D. Exterior storm sewer piping and fittings below ground (l5" and larger): reinforced concrete pipe ASTM C76, C655 and AASHO M-170. Joints; rubber and mortar type ASTM C443, C361. Piping and components shall comply with HS-20-44 loading requirements.

E. Domestic hot water, cold water, hot water recirculating, condensate, and indirect waste piping above ground: hard drawn seamless Type L copper tubing ASTM B88 with wrought copper solder fittings A.N.S.I. B16.22 and "Bridgit" or other no lead content solder joints ASTM B32-83, alloy Grades SN96 or SB5. Solder flux lead content-zero percent.

F. Domestic hot water, cold water, and hot water recirculation piping below ground: pre-insulated pre-fabricated and factory tested piping system consisting of Type K copper tubing hard temper ASTM B88, and wrought copper solder fittings ANSI B16.22 with lead free solder, non-compressible polyurethane insulation (K-Factor 0.14), 2" thickness and PVC outer jacket. Ricwil Econo-Gard piping systems.

G. Water service piping from well casing shall be Schedule 40 polyethylene 200 PSI water service piping ASTM D-2737, manufactured by Hastings. Fittings shall be Mueller 110 compression type.

H. Gas piping (up to and including 2" size): schedule 40 black steel ASTM A106, threaded end ANSI B1.20.1, with class 150 malleable iron threaded fittings ANSI B16.3.

I. Gas piping (over 2" size): schedule 40 black steel ASTM A106, with schedule 40 butt weld fittings.

J. Underground gas service piping: plastic piping conforming with "standard specifications for thermoplastic gas pressure pipe, tubing, and fittings" ASTM D2513. Pipe shall be marked "GAS" and "ASTM D2513". Piping shall be installed in accordance with NFPA 54, and manufacturer's requirements.

2.02 PIPE HANGERS, SUPPORTS, SEISMIC RESTRAINT, AND VIBRATION ISOLATION

A. Pipe hangers and supports: refer to Section 230523.

B. Seismic restraint: refer to Section 230000 and 230548.

C. Vibration isolation: refer to Section 230548.

2.03 INSULATION

A. Insulation and sound attenuation: refer to Section 230700.

2.04 VALVES

A. General: refer to Section 230523 for general plumbing service valves.

1. Domestic water systems up to 2-1/2"size: Nibco T-595-Y, 3 piece, full port, bronze threaded, 600 psi WOG.

2. Domestic water systems sizes 3" and over: Class 125, IBBM, gate valve.

3. Check valves for domestic water systems up to 2-1/2" size: class 125 all bronze, silent type, threaded.

4. Check valves for domestic water systems sizes 3" and over: class 125 IBBM flanged, silent check valve.

5. Balancing valve (domestic hot water circulation): all bronze, threaded end, calibrated stem, balancing ports, Armstrong CBVT series.

B. Backwater valves (BWV): Cast iron body with manual spade type bronze gate operated by a non-rising stem, integral check valve. Buried backwater valves equipped with cast iron extension collar and stem extending to top of slab or grade with nickel bronze top.

Manufacturer: Zurn model Z 1088.
Jay R Smith model 7150 series

C. Reduced pressure backflow preventers (RPD) - sizes 3/4" through 2": UL listed, AWWA, USC, and SBCCI/IAPMO approved bronze body reduced pressure zone air gap equipped with stainless steel relief and check valves, oversized copper funnel for pressure relief discharge piped to drain, bronze test cocks, integral body unions, bronze strainer and inlet and outlet ball valves.

Manufacturer: Watts 909 series, or HW-909 for hot water service.
Febco 825Y series.
Zurn/Wilkins 975XL series.

D. Reduced pressure backflow preventers (RPD) - sizes 2-1/2" to 4": UL listed, AWWA, USC, and SBCCI/IAPMO approved iron body reduced pressure zone air gap equipped with bronze relief and check valves, oversized copper funnel for pressure relief discharge piped to drain, bronze test cocks, complete with F.D.A. approved epoxy coated strainer and resilient wedge inlet and outlet gate valves.

Manufacturer: Watts 909 series.
Febco 825YD series.
Zurn/Wilkins 975 series.

E. Gas service valves: UL listed, for gas service, lubricated, semi-steel plug type, 100% pipe area, with threaded end ANSI B16.10 for up to 2"size, and 125 lb. ANSI B16.1 flanged for sizes over 2", 200 psi WOG.

Manufacturer: Homestead 6111/612 series.

F. Gas pressure regulating valves: Pilot controlled, and actuated. Sized for capacity and pressures as indicated on drawings.

Manufacturer: Rockwell 243-RPC series.

G. Water pressure regulating valve: the valve type shall be a fluid actuated pilot controlled pressure regulating valve equipped with a pressure sustaining feature that will cut out flow at a pre-set minimum pressure. The cut-off minimum pressure shall be set in the field, after a documented flow test and water supply curve is performed and plotted. The valve shall incorporate:

1. Bronze body.
2. Sealed FDA approved elastomer diaphragm.
3. Stainless steel spring and stem
4. Quad-ring flow throttling retainer.
5. Brass hydraulic control pilots.
6. Copper control tubing.
7. Full size FDA approved strainer and blow down valve.

8. Inlet and outlet pressure gauges with bleed shut off valves on the gauge stem.

Manufacturer: Watts 115-2 series.
Watts Regulator Co. ACV Div., Houston TX..
Cla-Val 92-01 series.

H. Hose end drain valve NIBCO Fig. No. T-113-HC, all bronze gate (Watts #B-6000-cc, all bronze ball valve) with 3/4" hose thread outlet, threaded cap, rubber gasket and safety chain.

2.05 PIPE SLEEVES AND SEALS

A. Masonry walls and slabs: Schedule 40 galvanized steel pipe with integral water stop.

B. Piping seal (interior walls in contact with earth): interlocking expandable synthetic rubber links, assembled with corrosion resistant bolts, nuts and pressure plates; "Link type seal".

C. Piping seal (interior walls and floors in contact with earth): interlocking expandable synthetic rubber links, assembled with corrosion resistant bolts, nuts and pressure plates; "Link type seal".

D. Piping seal (interior floor slabs in contact with earth): seal between pipe and sleeve with a flexible elastomeric caulk listed specifically as a pipe sealant.

E. Sleeve adapters: coated cast iron, equipped with flashing clamp.

F. Fire and smoke seal: UL listed, approved and tested fire and/or smoke sealing material installed in all fire and/or smoke rated floor and partitions in accordance with manufacturer’s recommendations. Refer to 230000.

2.06 DRAINS

A. General: Provide all poured in place drains with 24" x 24" vinyl flashing.

B. Floor drain toilet rooms (FD1): cast iron body, bottom outlet, 7" diameter nickel bronze top, trap primer connection, seepage pan and combination membrane flashing clamp.

Manufacturer: Smith 2010-A
Wade 1100STD
Zurn ZN-415- type B strainer

C. Floor drain mechanical rooms (FD2): heavy duty floor drain with, cast iron body, bottom outlet, 9" diameter cast iron top, trap primer connection, seepage pan and combination membrane flashing clamp.

Manufacturer: Smith 2120
Wade 1310
Zurn Z-508

D. Floor drain kitchens (FD3): white acid resistant enamel (ARE) coated interior 6" deep cast iron body, bottom outlet, 8" square nickel bronze top, white ARE interior bucket, seepage pan and combination membrane flashing clamp. Provide drains receiving indirect waste with 1/2 grate.

Manufacturer: Smith 3411-C series
Wade 9110 series
Zurn ZN-1910 series

E. Floor sink kitchens (FS): white acid resistant enamel (ARE) coated interior 8" deep cast iron body, bottom outlet, 12" square nickel bronze top, white ARE interior bucket, seepage pan and combination membrane flashing clamp. Provide drains receiving indirect waste with 1/2 grate.

Manufacturer: Smith 3151 series
Wade 9140 series
Zurn ZN-1901 series

F. Roof drain (RD): heavy duty drain with, 15" diameter cast iron body, bottom outlet, 12" diameter cast iron dome, roof sump receiver, under-deck clamp, insulation extension collar, and cast iron combination membrane flashing clamp/gravel guard.

Manufacturer: Smith 1010 series
Wade 3000 series
Zurn Z-100 series

G. Overflow Roof Drain (ORD): heavy duty drain with, 15" diameter cast iron body, bottom outlet, 12" diameter cast iron dome, roof sump receiver, 4” standpipe, under-deck clamp, insulation extension collar, and cast iron combination membrane flashing clamp/gravel guard.

Manufacturer: Smith 1070 series

2.07 CLEANOUTS

A. General: Provide all poured in place cleanouts with 24" x 24" vinyl flashing.

B. Floor cleanout (CO): areas incorporating floor finishes, adjustable round scoriated heavy duty nickel bronze secured top, cast iron body, flashing flange and clamp, tapered bronze plug.

Manufacturer: Smith 4020 series
Wade 6000Z series
Zurn ZN-1400 series

C. Floor cleanout (CO): exposed concrete floor areas, adjustable round scoriated heavy duty cast iron secured top, cast iron body, flashing flange and clamp, tapered bronze plug.

Manufacturer: Smith 4220 series
Wade 6000Z series
Zurn Z-1400 series

D. Floor cleanout (CO): carpeted areas, adjustable round scoriated heavy duty nickel bronze secured top, carpet marker, cast iron body, flashing flange and clamp, tapered bronze plug.

Manufacturer: Smith 4020 series
Wade 6000 series
Zurn ZN-1400 series

E. Floor cleanout (CO): exterior areas, adjustable round scoriated heavy duty cast iron top, cast ductile iron body, flashing flange and clamp, tapered bronze plug. Install cleanouts with 18" square x 6" deep concrete apron in non-paved areas.

Manufacturer: Smith 4250 series
Wade 8300MF series

F. Wall plate cleanout cover (WCO): provided at cast iron cleanouts with tapered bronze plug a 6" x 6" chrome plated nickel bronze square frame and plate secured with vandal proof screws.

Manufacturer: Smith 4730 series
Wade 8480ST series
Zurn ZANB-1460 series

2.08 PLUMBING FIXTURES

A. General: Fixtures shall be new, complete with trimmings and fittings, including faucets, carriers, supplies, stops, traps, tailpieces, waste plugs, casings, hangers, plates, brackets, anchors, supports, hardware and fastening devices.

B. Stainless steel: type 302, 304, 316, or 317, as noted, sound deadened.

C. Trimmings and fittings: construct of forged, cast, rolled or extruded brass or bronze with monel and other suitable non-corrosive parts: designed with easily renewable parts that are subject to wear or deterioration. No die castings and stampings other than brass or stainless steel. Plumbing trim shall consist of:

Exposed surfaces:	chrome plated. Pipe: copper type L.
Pipe fittings:	threaded bronze.
Supply stops:	chrome plated bronze, stuffing box, renewable seat washer.
Waste tailpiece:	minimum #17 gauge brass.
Escutcheons:	one-piece chrome plated cast brass or stainless steel.
Air Chambers:	Nibco #620-L. 12” long

D. Water closets (WCA or WCB): Wall-mounted, flushometer, standard and handicapped vitreous china, wall hung, 1.28 gpf low flow, elongated, siphon jet, with 1-1/2" top spud. Seat: heavy duty solid plastic elongated open front. Electric flush valve, combined concealed carrier and support. Color: white.

Fixture:	Toto CT708E(G)
Flushometer:	Toto TET1LN32

E. Urinal (URA or URB): wall hung, flush valve, standard and/or handicapped, vitreous china, 0.125 gpf, ultra-low flow, washout with 3/4” top stud, complete with electric flush valve and combination concealed carrier and support . Color: white.

Fixture:	Toto Ultra High-Efficiency Urinal and EcoPower Exposed Flush Valve

F. Under-Counter Lavatories (L1): Standard and Handicap Accessible. Vitreous china, counter mount, 1-1/2" chrome plated cast brass P-trap with cleanout plug, chrome plated brass angle stops with loose key operator, and grid drain. Faucet: chrome plated, hard wired, infrared sensor activated for hot and cold operation, 0.5 gpm vandal-proof aerator. Insulate trap and water piping below Handicap Accessible lavatories with insulation kit, install with 0.5 gpm aerator outlet. Color: white. 17-5/8"x13" basin.

Fixture:	Kohler "Archer" K-2355 with K-8998 P-Trap
Faucet:	Sloan EFX-2
Insulating kit:	Trubro 101

G. Conservation Sink (S1): A type 304 stainless steel double-compartment sink with left and right drain board, welded ¼" radius coved corner construction, full length 8" back splash, satin finish, NSF International certification.

Fixture: Elkay "Weldbilt" WNSF-8260-LR
Faucet: Chicago Faucets 631-RGN2A w/ 1.5gpm aerator

H. Hand Sink (S2): A type 304 stainless steel hand sink with full length 7" back splash, brushed finish and NSF International certification.

Fixture: Elkay CHS1716C
Faucet: Chicago Faucets 631-RGN2A w/ 1.5gpm aerator

I. Double Compartment Sink (S3): A type 304 stainless steel 20 gauge, self-rimming double compartment sink with 6-1/8" deep bowls, coved corners, satin finish, and fully undercoated.

Fixture: Elkay BPSR2317
Faucet: Elkay LK-2223.

J. Mop receptors (MR): 24" x 24" x 12" deep, terrazzo basin drain fitting and strainer, edge guard. Faucet: Wall mounted with bucket hook, vacuum breaker and wall bracket and hose thread end. Hose and bracket and mop hanger.

Fixture: Fiat TSB-100 series
Stern Williams SB-900 series
Florestone Model 80 series

Faucet: Chicago 897 series.
T&S B-66655-BSTR series.

Accessories: Hose Fiat 832-AA, mop hanger Fiat 889-CC, bumper guard Fiat 1239-BB, and strainer Fiat 1453-BB.

K. Electric Drinking Water Coolers (DF1 and DCH1): "Hi-Lo" wall mounted barrier free drinking fountain shall include dual 18 gauge Type 304 high polished stainless steel finish basins with integral swirl design, 14 gauge Type 304 high-polished stainless steel wall bracket, push-button operated stainless steel valves with front-accessible cartridge and flow adjustment, polished chrome-plated brass vandal-resistant waste strainers, vandal-resistant bottom plates, high-polished stainless steel finish back panel, high and low fountain mounting levels, 1-1/4" O.D. waste pipes, model 5725 EnviroGuard bubbler with polished chrome-plated solid brass bubbler head and stainless steel water activated pop up canopy, in-line lead removal filter element, support carrier and 8 gph remote chiller.

Manufacturer: Haws model 1011HPS

2.09 WATER HEATING EQUIPMENT

A. General: Water heaters shall conform to all applicable A.S.M.E. Standards and if gas fired Design Certified by the A.G.A. under Volume II "Tests for Commercial Heaters for Delivery of 140 Degrees F. Water", approved by the National Sanitation Foundation, and in compliance with ASHRAE 90.1-2007.

B. Domestic Water Heater (WH1): A gas-fired domestic water heater with submerged combustion chamber, helical heat exchanger coil, powered permanent anodes to protect the tank, glass lining on both sides of the heat exchanger, power-direct or conventional power venting and AMSE tank construction. The unit shall be capable of 95% thermal efficiency.

Manufacturer: A.O. Smith model BTH-199

2.10 PUMPS

A. General: refer to drawings for specific pump characteristics, (i.e. H.P., gpm, TDH, and Elec.).

B. Domestic hot water circulating pumps: UL listed, all bronze, in-line centrifugal pump, close coupled.

Manufacturer: Bell & Gossett 60 series.

C. Circulator controllers: UL listed, automatic immersion aquastat, adjustable temperature range, and differential immersion well. Electrical rating 115 VAC.

Manufacturer: Honeywell L4006A.

D. Domestic Pressure Booster Pump: Duplex, packaged system, UL listed, factory assembled, piped, wired and tested on a common groutable painted steel base frame. Pump packaged equipped with pumps rated at 150 gpm -70’TDH 5HP, stainless steel manifold piping, pressure (pilot) regulating/check valves, control panel, and 130 gallon 125psig ASME hydropneumatic tank.

Manufacturer: Auroroa.
Syncroflo.

E. Motor starters: UL listed, manual starting switch in NEMA 1 enclosure with "Hands-Off-Auto" selector switch. Refer to Section 230513.

2.11 WATER DETECTION SYSTEM

A. Cable water detection system: specification to follow.

B. Point water detection system: complete with water sensors, remote indicator panel and power supply. Include wiring between sensors and remote indicator.

Manufacturer: Water Alert SS-R(T) sensors, RI-2-(AT) remote indicator and PS-3 power supply.

2.12 MISCELLANEOUS PLUMBING SPECIALTIES

A. Mechanical mixing valves: bronze body, chrome plated, 3/8" inlet and outlet connections.

Manufacturer: Symmons #4-10 series.

B. Water hammer arrestors: all stainless steel, mechanical-pneumatic type, hermetically sealed bellows, threaded inlet; 150 psi WWP. Size and placement determination: PDI-WH 201.

Manufacturer: Precision Plumbing Products SC Series.

C. Air vent: bronze body, stainless steel trim and float, threaded inlet and outlet; 150 psi WWP.

Manufacturer: Sarco 13W series.

D. Trap primer valve: Automatic trap primer system including integral backflow preventer, flush or surface mounted cabinet, 120/220Vpower, pre-set 24 hour change, manual override switch, calibrated manifold for equal distribution. Locate manifolds per plumbing plans or as needed in mechanical rooms, janitor’s closets other locations approved by Architect and Engineer.

Manufacturer: Precision Plumbing Products PT series

E. Pressure gauge (PG): direct mounting, liquid filled, constructed with non-corrosive internal mechanism, recalibrator adjustment, assembled on 4-1/2" black phenolic turret type case with blow out plug, gasket sealed glass faced with dial, 0 to 200 psig range. Gauge accurate to 1% of scale range.

Manufacturer: Trerice 450LFB series.

F. Gauge valve: all bronze needle valve, 150 psi WWP.

G. Water filter: two-piece high impact strength plastic housing, 125 psi WWP, replaceable 5 micron filter cartridge. Equip on cold water supply to all electric water coolers.

Manufacturer: AMF CUNO 1M housing with G78B2 filter series.

H. Water filter Scale Inhibitor: scale inhibitor water conditioner, constructed of high impact strength plastic for 125 psi WWP, equipped with integral by-pass and replaceable cartridge filter element, 1 to 6 gpm flow range. Equip on cold water make-up supply to all HVAC equip.

Manufacturer: Filterite SI-4 series.

I. Vacuum breaker (pressure type): bronze body, silicone vent disc, silicone check valve disc with bronze seat, 1/4 turn bronze ball valve, IAMPO listed, USC tested. Note: do not locate vacuum breaker in concealed space. Provide and install oversized copper drain pan with indirect waste piped to drain receptor.

Manufacturer: Watts 800 series.

J. Vacuum beaker (non-pressure type): brass body, silicone disc.

Manufacturer: Watts 288 series.

K. Freeze proof hose bibb (FPHB): surface mounted wall hydrant with polished bronze face plate and bronze casing with "T" handle key and internal vacuum breaker. Size 3/4".

Manufacturer: Zurn Z-1310 series.
Smith 5609 series.
Wade 8600 series.

L. Freeze proof hose bibb (FPHB): recessed ground box type, bronze hydrant with polished bronze box (with 1/4" drain port in box), and bronze casting with "T" handle key and vacuum breaker. Size 3/4".

Manufacturer: Zurn Z-1360 series.
Smith 5810 series.
Wade 8602 series.

M. Hose bibb (HB): unfinished areas, bronze body, removable valve seat and stem assembly, threaded end and Watts NF8 vacuum breaker.

Manufacturer: Nibco #64 with Watts NF8 series.

N. Hose bibb (HB): finished areas, chrome plated bronze sill cock with "lock shield key", removable hand wheel, and vacuum breaker

Manufacturer: Nibco 763-LS series.

O. Overflow Storm Water Downspout: Type 304 Stainless Steel Downspout Cover with Hinged Perforated Cover.

Manufacturer: Smith 1775 series

2.13 ACCESS DOORS IN WALLS AND CEILINGS

A. At each valve, cleanout or plumbing device requiring access, furnish an access door for installation by other sections. Rigid construction with two hinges and a latch. In plenum ceilings, provide felt between the door and frame to make an air tight seal. Access doors shall be flush mounted, prime coated with rust inhibitive paint, concealed frame, flush screw driver operated locks with metal cams and anchors as required. Refer to division 8 for additional requirements.

Access door sizes shall be:
12" x 12" at easily accessible items.
16" x 16" where partial body access is required.
24" x 24" where full body access is required.

Manufacturer: Milcor type M series.
Cesco series.

2.14 DRIP PANS

A. Provide and install drip pans for piping as indicated on drawings and as required by actual field conditions where piping passes over including area within 3'-0" of electrical equipment. Refer to Section 233000 for materials.

PART 3 - EXECUTION

3.01 GENERAL

A. Drawings are diagrammatic and indicate a general arrangement of work. General design concepts indicated must be followed or bettered. Do not scale drawings. Consult Architectural and Structural drawings for space conditions. Develop and submit coordination drawings as outlined in Section 230000.

B. Manufacturer's qualifications: firms regularly engaged in the manufacturer of fixtures, appliances, pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

C. Material qualifications: shall conform to all local, state, and national/federal codes and regulations which may apply and nothing in these specifications shall be interpreted as an infringement of such codes or regulations.

D. Welding: qualify welding procedures, welders, and operators in accordance with ASME B31.1, or ASME B31.9, as applicable. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB).

E. Brazing: certify brazing procedures, brazers, and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Except for concrete, corrugated metal, hub-and-spigot, clay, and similar units of pipe, provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps through shipping, storage and handling, as required to prevent pipe-end damage, and eliminate dirt and moisture from inside of pipe and tube.

B. Where possible, store pipe and tube inside and protected from weather. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.

C. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

3.03 ELECTRICAL CONNECTIONS AND WIRING

A. Power wiring to electrical devices shall be installed by Division 26. The Plumbing Contractor shall be responsible to furnish all motor starters for installation by Division 26 and provide and install miscellaneous control and power wiring required by the equipment for proper and safe operation not specifically outlined in Division 26.

3.04 EQUIPMENT IN OTHER DIVISIONS AND/OR BY THE OTHERS

A. Kitchen, Laboratory, Laundry, and Darkroom equipment - Equipment shall be provided, set, assembled, and installed by Kitchen, Laboratory, Laundry, and Darkroom Contractor, except as noted below or on drawing.

B. Faucets and tailpieces and laboratory fittings shall be provided and set by other divisions. Piping connections shall be provided by Section 220000.

C. Section 220000 shall provide and/or install traps, stops, faucets, fittings, tailpieces, etc. including any miscellaneous trim and/or components not furnished by others but required for safe and proper operation, and connect the service

D. Obtain certified and approved prints of roughing drawings of equipment before starting work.

E. Coordinate and verify all equipment locations, connections, and equipment requirements with the appropriate Contractors (i.e. Kitchen, Laboratory, Laundry, Darkroom, etc.). Provide and install all piping and equipment necessary to operate all equipment properly and safely whether specifically shown or not.

F. All exposed piping, stops, cocks, and wastes which are visible to occupants shall be chrome plated.

G. Install gas piping, and gas piping specialties in accordance with NFPA 54, NFPA 58, and authorities having jurisdiction.

3.05 COORDINATION OF WORK

A. Carefully coordinate space requirements with other trades to insure that all materials can be installed in spaces allotted thereto, including finished suspended ceilings.

B. Prepare and submit coordination drawings as outlined in Section 230000.

C. Provide and install concrete housekeeping pads for all floor mounted plumbing equipment.

3.06 PIPING GENERAL

A. The word "piping" in this Specification shall mean pipe, fitting, flanges, nipples, and valves. Install underground piping as soon as possible so that trenches may be closed as quickly as possible.

B. No piping shall be covered until tested approved by the Authorities having jurisdiction.

C. Install all piping in correct relation thereto and the finished grades indicated on the drawings, and as required for coordination.

D. All piping shall be run perpendicular and/or parallel to floors, interior walls, etc. Piping and valves shall be grouped neatly and shall be run as to maximize headroom or passage clearance. All valves, controls and accessories concealed in

furred spaces and requiring access for operation and maintenance shall be arranged to assure the use of a minimum number of access doors.

E. All pipe lines made with screwed fittings must be provided with a sufficient number of flanges and/or unions to allow for easy and convenient dismantling of the system without breaking fittings.

F. Check the drawings for space limitations permitted for the installation of piping such as shafts, chases, and furred ceilings.

G. All piping shall run concealed in furred spaces of occupied areas or chases wherever construction permits. Contractor shall obtain permission from the Contracting Officer to run any exposed pipes.

H. All pipes shall be reamed to full area before installation and blown clear of chips and dirt. With threaded pipes apply compound to the male thread only.

I. Cap all pipe and equipment outlets during construction and keep lines and inside of equipment free of foreign materials. Provide for expansion without warping or dislocating lines or straining connected equipment. Install piping to clear building construction and to avoid interference with other work.

J. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the drawings or required to complete the installation intended by these specifications.

K. The drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset as required to meet field conditions.

L. This Contractor shall inform himself from the general construction specifications and plans, of the exact dimension of finished work and of the height of finished ceilings in all rooms where equipment or pipes are to be placed and arrange his work in accordance with the schedule of interior finishes, as indicated on the architectural drawings.

M. All piping below grade or building slab shall be coated with coal tar enamel.

N. Provide and install identification of piping and valves. Refer to other Division 23 Sections for installation requirements.

O. Provide and install additional pipe protection (i.e. concrete encasement, and /or laying condition, bedding type and methods.) for underground piping subject to excessive loading by depth of bury, traffic or other sources.

P. Underground piping shall be coordinated with concrete piers, footings and grade beams. Piping shall not be located adjacent to the concrete structure's bed closer than a 45 degree angle from the bottom of the concrete structure. Piping running below a wall footing or grade beam shall have a minimum non-bearing clearance of 6" above the pipe to the bottom of the concrete structure.

3.07 PRESSURIZED PIPING

A. Exterior water piping shall be installed at least 5'-0" below grade to top of pipe.

B. Water piping shall be run free of traps and unnecessary bends. Any traps formed shall be provided with hose end drain valves with threaded cap and chain to completely drain the system.

C. Install water hammer arrestors on water systems in accordance with manufacturer's recommendations.

D. Provide section cut-off valves on all main branches or as shown. Pitch and valve all water piping for convenient drainage.

E. Wherever dissimilar metals are joined together an approved dielectric fitting shall be used.

F. Each sectional shut-off shall have a brass tag and copper wire with a number. A chart shall be made up for each system setting forth the number of valves and what fixture it controls. Chart to be placed in glass frame and hung in Mechanical Equipment Room. Refer to Section 230000 for piping and valve identification requirements.

G. Balance domestic hot water recirculation systems to maintain temperature throughout entire system.

3.08 DRAINAGE PIPE INSTALLATION

A. Run all soil, waste and vent piping shown or required by local codes. Piping shown is minimum and in accordance with State and Federal codes. If local codes require additional venting or larger sizes, same shall take precedence.

B. Make all connections through traps. Each trap to be vented, either by circuit, loop, or individual vent, as required, but not less than shown, or as required by local code.

C. Install exterior underground sanitary and storm drainage piping at least 36 inches below grade to top of pipe unless otherwise specifically indicated.

D. Vent pipes shall be graded to free themselves of any water or condensation. Pitch vents not less than l/8" per foot up toward stack.

E. Install exterior cleanouts with a 18" square x 6" thick concrete apron.

F. Pitch horizontal storm water and drains within or buried under the building not less than l/8" per foot unless otherwise indicated on drawings.

G. Pitch horizontal sanitary and waste piping at 1/2" per ft. slope for piping 1-1/2" or less; 1/4" per ft. slope for piping 2" and 3" diameter; and 1/8" per ft. slope for piping 4" to 6" diameter.

H. Piping shall be laid true to line and grade as shown on the drawings, and in such a manner that a true and even surface at the invert is made over joints and throughout the entire length of the line. Piping shall be graded by the tripod level and measuring rod method assuring a uniform slope of the pipe.

I. All underground piping shall be laid on 6" sand and backfilled with clean fine earth compacted to 12" above pipe. Complete backfill with available earth free of large boulders and sharp rocks. Tamp backfill in 6" elevations and overfill to allow for settlement.

3.09 PIPING SUPPORT

A. General

1. Refer to Sections 230000, 230523, and 232000 for general requirements.

2. Protection shields shall be provided under all horizontally insulated piping at each hanger.

3. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations.

B. Horizontal piping support

1. Cast iron soil pipe shall be supported at not more than 5-foot intervals. Supports shall be of ferrous material.

2. Copper tubing shall be supported at approximately 6-foot intervals for piping l-l/2" and smaller and 10-foot intervals for piping 2" and larger. Supports shall be of copper material.

C. Vertical piping support

1. Cast-iron soil pipe. Cast iron soil pipe shall be supported at not less than every story height and at its base. Supports shall be of ferrous material.

2. Bases of cast iron soil stacks shall be supported on concrete, or metal brackets attached to the building structure, or any other methods designed to eliminate stress at the base of stacks and leaders approved by the local administrative authority.

3. Copper tubing shall be supported at each story for piping l-l/2" and over and not more than 4-foot intervals for piping l-l/4" and smaller. Supports shall be of copper material.

3.10 INSULATION

A. Refer to Section 230700 for installation requirements.

3.11 VALVES INSTALLATION

A. Refer to Section 203523 for general requirements.

B. Do not install air gap backflow preventers in concealed spaces or in areas where splashing water will damage finishes. Provide and install an oversized copper funnel with air gap directly below RPD pressure relief port. Pipe funnel to spill as an indirect waste to an approved drain location.

C. Install all trap primer valves in an accessible location. Provide and install access panels and doors where required to gain access in concealed construction.

3.12 SLEEVE INSTALLATION

A. Refer to Section 230000and 230523 for general requirements.

B. All piping through walls, floors or ceilings shall have sleeves and escutcheons.

C. All piping penetrating a slab on grade or foundation wall below grade and in contact with earth shall be provided with a poured in place schedule 80 galvanized steel water tight sleeve with integral water stop and seal equal to "link seal".

D. Furnish and set steel pipe sleeves of schedule 40 black steel for all locations of interior partitions, walls and floors providing at least 1/2" clearance between pipe insulation and sleeve or pipe and sleeve. Wall sleeves shall be smooth cut and set flush with finished walls. Floor sleeves shall extended 2" above the finished

floor. Provide a two-piece chrome escutcheon where piping passes through walls or floors of finished spaces.

E. Fill void spaces between piping and pipe sleeves penetrating fire/smoke walls and floors with an approved UL listed and fire tested sealing material.

3.13 DRAIN AND CLEANOUT INSTALLATION

A. General: Provide and install all drains and cleanouts with 6# 24" x 24" vinyl flashing.

B. Make all connections through traps. Each trap to be vented, either by circuit, loop, or individual vent, as required, but not less than shown, or as required by local code.

C. Cleanouts shall be installed at the base of all stacks, at all changes of directions greater than 45 degrees and in runs to provide means of cleaning lines at maximum 50' intervals.

D. Coordinate floor drain locations with respect to equipment housekeeping pads. Place drains such that edge of the floor grate extends no further than 2 inches from the side of the pad.

3.14 PLUMBING FIXTURES

A. The fixtures shall be furnished complete with chrome plating on exposed piping or trim. Provide anchor bolts, hangers, strainers, faucets and other incidental items furnished as standard. Provide loose key stops at every fixture. All supply fittings and exposed fixture trim shall be all brass, chrome plated.

B. All fixtures are to be new, free of cracks, blemishes or other imperfections and to be "acid-resisting" quality.

C. Set and properly connect all fixtures with hot and cold water, vent and drainage piping, as required and protect fixtures until acceptance and test. Clean all flush valves after two weeks of operation.

D. All piping through walls, floors or ceilings shall have sleeves and escutcheons.

E. Provide all fixture mounting supports and carriers as required to suit field conditions. Carriers and supports shall be floor mounted type except as noted.

F. Examine roughing-in work of potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures. Correct any incorrect location of piping, and other unsatisfactory conditions for installation of plumbing fixtures. Do not proceed with work until unsatisfactory conditions have

been corrected in a manner acceptable to the engineer. All rough-in to plumbing fixtures shall conform to fixture manufacturer published rough-in dimensions, and requirements.

G. Adjust all plumbing fixtures, faucets and flush valves to meet the maximum water consumption requirements listed herein.

Water closets:	1.6 gallons per flush
Urinals:	1.0 gallons per flush
Lavatory:	0.5 gpm flow restrictor
Showers:	2.5 gpm

H. Upon completion of installation of plumbing fixtures and after units are water pressurized, test fixtures to demonstrate capability and compliance with requirements. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.

I. Inspect each installed unit for damage to finish. If damaged, restore and match finish to original at site to the satisfaction of the Architect/Engineer; otherwise, remove fixture and replace with new unit. Remove cracked or dented units and replace with new units.

J. Clean plumbing fixtures, trim, and strainers of dirt and debris upon completion of installation.

K. Adjust water pressure at drinking fountains, faucets, shower valves, and flush valves to provide proper flow stream and specified gpm.

L. Exercise care in handling of fixtures, trim, pipe, and fittings. Use tools designed to prevent damage to surface finishes.

M. Set fixtures level and uniformly, with connections at right angles to wall and properly centered. Lay out roughing accurately and in coordination with space and finish requirements. If field cut-outs and holes are required use proper cutting and drilling tools to maintain integrity of finished surface. Provide cut-out templates for countertop insert or undermount items.

N. Locate waste outlets and water supplies at constant horizontal levels, with waste outlet centered on fixture drain connection and water supplies spaced equally to right and left.

O. Support wall hung fixtures rigidly from building construction, not from piping, by means of concealed metal supporting members designed to carry weight of fixture under conditions of unusual loading, with no stress placed on waste connection or any other part of system.

P. Secure floor mount supports to slab. Secure wall mount supports to 1/4 inch thick metal backup plate secured to wall construction. Do not use wire, nails, or other makeshift devices to secure supporting members. Secure recessed and inserted items to supporting surface.

Q. Use vandal-proof devices to secure fixtures, trimmings and fittings to deter unauthorized removal. Provide chrome plated brass washers and cap nuts for exposed bolt ends.

R. Provide escutcheons, threaded or held in place with threaded part or set screw, on piping and fixture supports protruding from wall or floor, and on visible connections to fixtures.

S. Make connection between integral trapped fixtures and drainage piping with an approved prepared gasket that shall be a germicide, absolutely gas and fume-proof, watertight, stainproof, containing neither oil or asphaltum, and which will not rot, harden, or dry under any extreme of climatic change, and must adhere on wet surfaces.

T. Use non-ferrous spacing devices to support and stabilize water piping.

U. Paint non-coated ferrous metal surfaces of fixtures, including brackets, hangers, and plates with prime coat of paint.

V. Upon completion of work, remove protective covers and thoroughly clean surfaces, traps and strainers. Check all items for proper operation. Tighten packings and retaining devices.

W. Adjust flush valves to provide minimum flow consistent with cleaning requirements of fixtures. Adjust supplies to provide adequate flow without splashing, and with flow rate of hot and cold water equal in velocity, except as otherwise required.

3.15 INDIVIDUAL SIZES OF BRANCHES TO FIXTURES

	COLD	HOT	WASTE	VENT
Water closets(tank)	1/2"	---	4"	2"
Water closets(flush val)	1-1/4"	---	4"	2"
Urinals (flush valve)	1"	---	2"	1-1/2"
Lavatories	1/2"	1/2"	1-1/2"	1-1/2"
Electric water coolers and drinking fountains	1/2"	---	1-1/2"	1-1/2"
Hose bibbs	3/4"	--	---	---
Clothes washer	1/2"	1/2"	2"	1-1/2"

Service sink or mop receptor	3/4"	3/4"	3"	1-1/2"
Sinks	1/2"	1/2"	2"	1-1/2"
Showers	1/2"	1/2"	2"	1-1/2"
Tubs	1/2"	1/2"	1-1/2"	1-1/2"

3.16 ROUGHING HEIGHTS

A. Above Finished Floor

Lavatories	31" to top of rim
Urinals	24" to top of rim
Water closets	l5" to top of rim
Electric water coolers and drinking fountains	33" to top of rim
Hose bibbs	24" to bottom of spout

B. Handicap fixtures shall be set in accordance with ADA and local requirements.

3.17 EQUIPMENT IN OTHER DIVISIONS AND/OR BY OWNER

A. Plumber shall provide and install traps and stops and install faucets and tailpieces and connect the service as required.

B. Plumber shall obtain certified prints of roughing drawings of equipment before starting work.

3.18 GAS SYSTEMS

A. General: Conform to the requirements of NFPA 54.

B. Provide dirt trap, gas cock, and union at each connection to each piece of equipment.

C. Locate gas piping with adequate separation between electrical cables, equipment, and conduit.

D. Slope gas piping to low points without traps. Provide drips (pipe tee, nipple, and cap) at bottom of all vertical risers and drops.

E. Make branch connections to mains from top or side, not from bottom of main.

F. Extend unthreaded portions of piping at least 2 inches through finished wall surfaces, floors, ceilings and sleeves.

G. Provide and install gas shut-off valves for the proper and safe control of the system.

H. DO NOT locate gas valves in spaces used as air plenums.

I. Verification: before making a gas connection, verify that equipment is compatible with the type and pressure of gas being supplied.

J. Purging: purge gas to safe location.

3.19 THRUST BLOCKS AND BRACING

A. General: Conform to the requirements of NFPA 24.

B. Thrust blocks for water piping shall be provided at all changes in direction both horizontally and vertically. Thrust blocks shall bear against undisturbed earth or earth installed in accordance with NFPA 24.

C. Use rough forms along ends of concrete. Place concrete directly against fittings to be braced, and directly against undisturbed surface of trench wall. Do not encase fittings in concrete.

3.20 PENETRATIONS THROUGH FIRE SEPARATIONS

A. Fire and smoke seal: UL listed, approved and tested fire and/or smoke sealing material installed in all fire and/or smoke rated floor and partitions in accordance with manufacturer's recommendations.

3.21 DISINFECTION OF POTABLE WATER SYSTEM

A. Potable water systems shall be disinfected in accordance with State and Local codes but by not less than one of the following methods before it is placed in operation.

B. The system, or part thereof, shall be filled with a solution containing 50 parts per million of available chlorine and allowed to stand 24 hours before flushing and returning to service.

C. The system, or part thereof, shall be filled with a solution containing 200 parts per million of available chlorine and allowed to stand 3 hours before flushing and returning to service.

3.22 TESTS

A. General: Test plumbing systems to satisfaction of Building Official. Do not close in, conceal, or cover up any plumbing work until it has been tested, inspected, and approved.

B. Flush piping, prior to testing, to remove foreign materials which may have entered during course of installation. Clean filters and strainers after flushing.

C. Test all piping except drainage and vent piping, including valves, fittings and joints hydrostatically at a pressure equal to at least l-l/2 times the normal working pressure of the system under which it is to be used, but no less than 100 psig for a minimum of four hours. Blank off or remove all elements or equipment which may be damaged by the pressure. Open but do not back-seat valves. Inspect all joints and connections.

D. Test rough plumbing drainage and vent system with water or air at least as follows:

1. Water test: apply water test to drainage system either in its entirety or in sections. If applied to entire system, tightly close all openings in piping, except highest, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, and fill section with water. In testing successive sections at least upper 10 feet of next preceding section shall be tested, so that no joint or pipe in building (except uppermost 10 feet of system) shall have been submitted to a test of less than a 10 foot head of water. Keep water in system or in portion under test, for at least 15 minutes before inspection starts; system shall then be tight at all points.

E. Final test for gas and water tightness to be as follows:

1. Smoke test: fill all traps with water, and then introduce into the system a pungent thick smoke produced by one or more smoke machines. When the smoke appears at stack openings on the roof, they shall be closed, and a pressure equivalent to one inch water column shall be held for the test and inspection period.

F. Test all gas piping in accordance with NFPA 54 Section 4 with no leakage noted. Coordinate test procedure and requirements with local utility company.

G. Repair all leaks, defects or damage revealed by the results of the testing and re-test the system.

H. Do not insulate or conceal piping until the system has been tested and the results approved.

I. Perform tests in the presence of the Authority Having Jurisdiction. Notify Architect and/or Engineer.

3.23 TRAINING

A. Provide field training course for Owner's designated personnel.

B. Training shall be provided for a total period of at least (8) hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests.

C. Field training shall cover all of the items contained in the operation and maintenance manuals.

END OF SECTION 22 00 00

SECTION 22 08 00 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The OPR and BOD documentation are included by reference for information only.

C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.

B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:

C. Certificates of readiness

D. Certificates of completion of installation, prestart, and startup activities.

E. O&M manuals

F. Test reports

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. **Red-lined Drawings:**
1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. **Operation and Maintenance Data:**
1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
2. The CxA will review the O&M literature once for conformance to project requirements.
3. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the contractor.

D. **Demonstration and Training:**
1. Contractor will provide demonstration and training as required by the specifications.
2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.

4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
7. Review data in O&M Manuals.

E. **Systems manual requirements:**

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The GC shall include final approved versions of the following information for the Systems Manual:
    a. As-Built System Schematics
    b. Verified Record Drawings
    c. Test Results (not otherwise included in Cx Record)
    d. Periodic Maintenance Information for computer maintenance management system
    e. Recommendations for recalibration frequency of sensors and actuators
    f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
    g. Training Records, Information on training provided, attendees list, and any on-going training
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meetings.

C. Attend domestic water balancing review and coordination meetings.

D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

G. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

H. Update schedule as required throughout the construction period.

I. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

J. Assist the CxA in all verification and functional performance tests.

K. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

L. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.

M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

N. Notify the CxA a minimum of (2) weeks in advance of the time for start of the balancing work. Attend the initial balancing meeting for review of the balancing procedures.

O. Participate in, and schedule vendors and contractors to participate in the training sessions.

P. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Plumbing equipment including domestic water heaters, pumps, and domestic water piping.

Q. The equipment supplier shall document the performance of his equipment.

R. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

S. Balance Contractor
   1. Attend initial commissioning coordination meeting scheduled by the CxA.
   2. Submit the site specific balancing plan to the CxA and Design Professional for review and acceptance.
   3. Attend the balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in balancing the Plumbing system.
   4. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.
   5. At the completion of balancing work, and the submittal of the final balancing report, notify the Plumbing Contractor and the CM/GC.
   6. Participate in verification of the balancing report, which will consist of repeating measurements contained in the balancing reports. Assist in diagnostic purposes when directed.

T. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

U. Equipment Suppliers
   1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
   2. Assist in equipment testing per agreements with contractors.
   3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

V. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 DOMESTIC WATER BALANCING VERIFICATION

A. Prior to performance of Domestic Water Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of Plumbing systems at the direction of the CxA.

1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
2. The balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final balancing report.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. **Plumbing Instrumentation and Control System Testing:** Assist the CxA with preparation of testing plans.

C. **Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment:** Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Domestic Hot Water System
2. Domestic Water Heater
3. Hot Water Circulating Pump
4. Hot Water Tempering Station Plumbing Fixtures

3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.12 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.14 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

B. **Plumbing Contractor.** The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of Plumbing equipment.
3. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
4. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
5. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
6. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
7. The plumbing contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls.
8. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

END OF SECTION 22 08 00

SECTION 221313 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Nonpressure and pressure couplings.
3. Expansion joints.
4. Cleanouts.
5. Encasement for piping.
6. Manholes.

1.2 ACTION SUBMITTALS

A. Product Data: For expansion joints.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

C. Field quality-control reports.

PART 2 - PRODUCTS

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

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

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

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

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

B. CISPI-Trademark, Shielded Couplings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. ANACO-Husky.
b. Dallas Specialty & Mfg. Co.
c. Fernco Inc.
d. Mission Rubber Company; a division of MCP Industries, Inc.
e. Stant; a Tompkins company.
f. Tyler Pipe.

3. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Shielded Couplings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. ANACO-Husky.
b. Clamp-All Corp.
c. Dallas Specialty & Mfg. Co.
d. Mission Rubber Company; a division of MCP Industries, Inc.
e. Stant; a Tompkins company.
f. Tyler Pipe.

3. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F 949, PVC corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F 477, elastomeric seals.

B. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D 3034, SDR 35 or As Indicated, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

2.4 CONCRETE PIPE AND FITTINGS

A. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 1 , with bell-and-spigot or tongue-and-groove ends for gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets.

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).

1. Bell-and-spigot or tongue-and-groove ends for gasketed joints, with ASTM C 443 (ASTM C 443M), rubber gaskets.
2. Class II, Wall A.
3. Class III, Wall A.
4. Class IV, Wall A.
5. Class V, Wall A.

2.5 NONPRESSURE-TYPE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
3. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Ring-Type, Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.6 EXPANSION JOINTS

A. Ductile-Iron, Flexible Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. EBAA Iron, Inc.
    b. Romac Industries, Inc.
    c. Star Pipe Products.

3. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.

2.7 CLEANOUTS

A. Cast-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

1. Top-Loading Classification(s): Light Duty and Heavy Duty.
2. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

2.8 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) or high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm)] minimum thickness.

C. Form: As Indicated

D. Color: As Indicated

2.9 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
4. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.

5. Riser Sections: 4-inch (100-mm) minimum thickness, of length to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP ; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
10. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser, with 4-inch- (100-mm-) minimum-width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
2. Material: ASTM A 536, Grade 60-40-18 ductile iron unless otherwise indicated.

2.10 CONCRETE

A. General: Cast-in-place concrete complying with ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

    a. Invert Slope: 2 percent through manhole.

2. Benches: Concrete, sloped to drain into channel.

    a. Slope: 8 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure, drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 0.45 percent unless otherwise indicated.
2. Install piping 8 inches and larger with manholes at changes in direction.
3. Install piping with 36-inch (915-mm) minimum cover unless otherwise indicated.

4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install PVC corrugated sewer piping according to ASTM D 2321 and ASTM F 1668.
7. Install PVC Type PSM sewer piping according to ASTM D 2321 and ASTM F 1668.

G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Hub-and-spigot, cast-iron soil pipe.
2. Hubless cast-iron soil pipe and fittings.
3. Expansion joints.

H. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join PVC corrugated sewer piping according to ASTM D 2321.
5. Join PVC Type PSM sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
6. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
7. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
8. Join dissimilar pipe materials with nonpressure-type, flexible[or rigid] couplings.

B. Pipe couplings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.

    a. Unshielded flexible couplings for pipes of same or slightly different OD.
    b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.4 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Install FRP manholes according to manufacturer's written instructions.

D. Form continuous concrete channels and benches between inlets and outlet.

E. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 2 inches (50.8 mm) above finished surface elsewhere unless otherwise indicated.

F. Install manhole-cover inserts in frame and immediately below cover.

3.5 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

3.6 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 6 inches (450 by 450 by 150 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.7 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 221316 "Sanitary Waste and Vent Piping."

B. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).

2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

    a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Connect to [grease] [oil] [and] [sand] interceptors specified in Section 221323 "Sanitary Waste Interceptors."

3.8 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.9 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.

e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:

a. Fill sewer piping with water. Test with pressure of at least 10-foot (3-m) head of water, and maintain such pressure without leakage for at least 15 minutes.
b. Close openings in system and fill with water.
c. Purge air and refill with water.
d. Disconnect water supply.
e. Test and inspect joints for leaks.

6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
b. Option: Test concrete gravity sewer piping according to ASTM C 924 (ASTM C 924M).

7. Manholes: Perform hydraulic test according to ASTM C 969 (ASTM C 969M).

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 221313

SECTION 23 00 00

GENERAL PROVISIONS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this Division shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install all work of this Division as shown on the drawings, as specified herein, and/or as required by job conditions.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

C. Perform the work in accordance with the above requirements and the provisions of all applicable codes and laws.

D. Standard Specifications and Abbreviations

E. The following abbreviations used in the Specifications refer to organizations publishing specifications and standards. These shall be construed to mean the latest standard adopted and published at the date of advertisement for bids and such specifications are made part of the Contract Documents to the same extent as if written out in full.

ADA	Americans with Disabilities Act
ADC	Air Diffusion Council
AHDGA	American Hot Dip Galvanizing Association
AISC	American Institute of Steel Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ARI	American Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
FIA	Factory Insurance Association
FM	Factory Mutual
FS	Federal Specifications

IGSPHA	International Ground Source Heat Pump Association
MCAA	Mechanical Contractors Association of America
MSS	Manufacturers Standardization Society of Valve and Fittings Industry
NBFU	National Board of Fire Underwriters
NBS	National Bureau of Standards
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety Health Act
PDI	Plumbing and Drainage Institute
PPI	Plastics Pipe Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
SSPC	Steel Structures Painting Council
STI	Steel Tank Institute
UL	Underwriters Laboratories, Inc.
USDC	United States Department of Commerce
USPHS	United States Public Health Service

1. Conform to ANSI - 31.1.0 and addenda for basic materials and methods of installation for closed piping systems with pressures in excess of 30 PSI, and for pipe welding regardless of system pressures.

2. Conform to ASME Boiler and Pressure Vessel Code Section VIII and FM requirements for construction of unfired pressure vessels.

1.02 INTENT

A. It is the intention of the specifications and drawings to provide for finished work, tested and ready for operation, subject to the requirements of the contract documents, including but not limited to Paragraphs 1.02 B, C and D below.

B. Items and services not shown on drawings, but mentioned in specifications, or vice versa, necessary to render the work complete and ready for operation, shall be provided without additional cost to the Owner.

C. Where conflicts occur between drawings and specifications, or within either document, the Contractor shall ask for and obtain a written clarification from the Architect prior to submitting his bid. Otherwise, the items or arrangements of superior quality, greater quantity or higher cost shall prevail and be included in the contract price.

D. The drawings show, among other things, the intent of the system components and routing. Some fittings and accessories are shown, but it is not the intent to show all similar or other fittings and accessories that will be required in order to install the systems in a coordinated way, as finished work. The contractor shall include all fittings and accessories as may be required in order to accomplish the coordination of the various building systems, to ensure the systems fit within the spaces provided, regardless of whether these fittings and/or accessories are shown on the drawings.

1.03 WORK INCLUDED

A. The work under this Division shall include all labor, material, equipment plant, services and administrative tasks required to complete and make operable the mechanical work shown on the Drawings and specified herein, including but not limited to, the following:

1. Preparation and submission of shop drawings, diagrams and illustrations.

2. Procuring all necessary permits and approvals, and paying all required fees and charges in connection with the work of this Division.

3. Protection, testing, cleaning, adjustment and guarantee of the work of this Division to safely, properly and continuously operate.

4. As-built drawings, operating and maintenance instructions and manuals.

5. Identification labels, tags, charts and diagrams.

1.04 RELATED WORK

A. Section 01015 – Volatile Organic Compound (VOC) Limits for Adhesives, Sealants and Architectural Coatings

B. Section 01300 – Submittals

C. Section 01515 – Construction IAQ Management

D. Section 01570 – Construction Waste Management

1.05 WORK NOT INCLUDED

A. Finish patching of all construction cut under this Division.

B. Waterproofing of roof penetrations for the work of this Division.

C. Concrete and masonry work except as specified.

D. Painting, except as noted.

1.06 SITE INVESTIGATION

A. Examine the drawings and specifications of all trades, and the site, and from these investigations be responsible for the nature and location of work, general and local conditions, particularly those bearing upon transportation, disposal, handling and storage of materials, availability of labor, water, electric power, roads, etc.

1.07 DRAWINGS

A. Drawings are diagrammatic and indicate the general arrangement of systems and work required. Do not scale the Drawings. Consult the architectural drawings and details, and the drawings of other trades, for exact location of equipment.

B. Drawings shall be used in layout of work. Check reference drawings to verify spaces in which the work will be installed. Maintain maximum headroom and space conditions. Where headroom or space conditions appear inadequate, Architect shall be notified before proceeding with installation.

C. If directed by the Architect, make minor modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.

D. The drawings are schematic and diagrammatic.

1. Symbols and diagrams are used to indicate the various items of work and the complete systems, but not necessarily have dimensional significance; neither do they necessarily delineate all related and subsidiary parts and equipment.

2. The work shall be installed complete and ready for operation in conformity with the intent expressed on the drawings and in the specifications.

3. Coordinate the work with the requirements of the architectural and structural drawings for dimensions, locations and clearances.

4. Locations of items exposed to view shall be taken from the architectural drawings or located as directed.

1.08 COORDINATION WITH OTHER TRADES

A. Closely schedule the work so that work will be installed at the proper time without delaying the completion of the entire project.

B. Where the work will be installed in close proximity to the work of other trades, or where there is evidence that the work will interfere with the work of other trades, arrange space conditions to make a satisfactory adjustment. If work is installed before coordinating with other trades, make necessary changes to the work to correct the condition without additional cost to the owner.

C. Prepare complete set of drawings showing all necessary slab openings and structural supports that require structural framing. Drawings shall clearly indicate sizes and location relative to established column lines. Drawings shall be completed in sufficient time to allow for structural steel fabrication so as not to delay project schedule.

D. Shop drawing submissions shall demonstrate a knowledge of the work of other trades, and shall show the locations of the work of other trades which affects the work of this contract.

1.09 EQUIPMENT DEVIATIONS

A. Where an item of equipment is proposed, other than that detailed or specified on the drawings, which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical or electrical layouts, such redesign, and new drawings required therefore, with approval of the Architect, shall be prepared without cost to the Owner.

B. Where such approved deviation requires a different quantity and arrangement of equipment from that specified or indicated on the drawings, provide required equipment, wiring, piping, connections, valves, and structural supports, and any other additional equipment required by the deviation, at no additional cost to the Owner.

C. It is the intent of these specifications that wherever a manufacturer of a product or a catalog number is specified, and terms "or equal" or "or approved equal" are used, the substituted item must conform in all essential respects to the specified item including operating efficiency, noise generated, and method of operation. Consideration will not be given claims that the substituted item meets performance requirements with lesser construction. Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance.

1.10 EQUIPMENT AND SYSTEMS CRITERIA

A. The criteria of design and performance to produce the required operation are based on equipment shown or scheduled.

B. The equipment must conform to the structural design provisions for loads applied to the structure, to the dimensions established by drawings for machine spaces and other clearances, and for inlet and outlet locations and proper relationship to associated equipment, piping and ducts.

C. The descriptions cover basic equipment and operation but not all the details of design and construction.

D. The use of singular in descriptions does not limit the quantities of items to be furnished to provide the operation specified. Furnish all equipment required to produce specified performance under installed conditions.

E. Factory wiring, interconnections, piping and connections shall conform to these specifications for the field work.

F. Provide all trim, enclosures and accessories required to make a complete installation.

G. Finish mechanical equipment, motors, controls and similar apparatus with machinery enamel, prime coat and finish coat. Provide prime coat suitable for field painting and other protective treatments and coatings as specified.

H. Acoustical performance of equipment and systems.

1. Noise levels from operation of motor driven equipment, whether air-borne or structure-borne, and noise levels created by or within air-handling equipment and air distribution and control media shall not exceed sound pressure levels determined by the noise criterion curves in the ASHRAE Guide as follows:

Location	Noise Criterion
Offices	NC 35
Corridors	NC 40
Toilets	NC 40
Galleries	NC 30
Orientation Theater	NC 30

2. Testing for conformance to the above requirements will be provided by an acoustical consultant retained by the Owner.

3. Octave band sound pressure levels will be obtained for ambient room conditions with equipment not operating and also with the installed equipment operating per plans and specifications.

4. For testing purposes, sound pressure levels will be measured 3'-0" above the floor.

1.11 APPROVALS

A. Obtain all approvals in accordance with Division 1 - General Requirements.

B. Submit to the Architect for approval a list of manufacturers of equipment proposed for the work.

C. Intent to use exact make specified does not relieve the Contractor of responsibility for submitting the required list.

D. Where any specific materials, process or method of construction, or manufactured article is specified by name or by reference to catalog number of a manufacturer, or other standards, the intent is not to take precedence over the basic duty and performance specified, noted on drawings, or as required for intended results. In all cases, verify the duty specified with the specific characteristics of the equipment offered for approval.

E. Equipment of one type shall be products of one manufacturer.

1.12 SUBMITTALS

A. Procedure

1. Prepare and make the submissions listed below in accordance with the procedure specified in this Section.

B. Shop drawings

1. Coordination Drawings.
2. Guarantees and Warrantees.
3. Operating and Maintenance Manual.
4. Record As-Built Drawings.
5. Identification Markings.
6. Fire rated penetration safing.

1.13 SUBMITTALS PROCEDURE

A. Refer to Division 1 - General Requirements for number of copies and routing procedure of submittals.

B. Shop drawings shall be submitted for each item listed in each specification section of this division or specified on plans.

C. Submittals shall include the following information on a cover sheet:

1. Job Name
2. Contractor's Name
3. Manufacturer's Name
4. Specification Section
5. Paragraph Number
6. Contractor Submission Number
7. List drawings and/or sheets included
8. List variations from specifications and drawings
9. Space for Engineer's and Architect's Review Stamp

D. Submittals shall consist of following applicable items:

1. Manufacturer's Drawings.

   a. Equipment listed in each section, include material specifications, operating characteristics and finishes.

2. Installation Drawings.

   a. Coordinated scale drawings of equipment including interconnecting piping and ductwork.

   b. Coordinate space requirements for equipment and services.

   c. Include connections, anchorages and fastenings.

   d. Make allowance for clearances for access to and maintenance equipment.

3. Wiring and Control Diagrams.

   a. Electric wiring diagrams and automatic control diagrams and sequences of operation. The wiring diagrams must be complete and coordinated with the equipment actually installed.

4. Provide composite shop drawings showing work of all related construction, when required to ensure full coordination and proper fitting of the work, and when directed by the Architect.

5. Provide drawings showing dimensions and locations of concrete work required for the mechanical work.

6. Samples: Color samples for prefinished items.

7. Reports:

   a. Manufacturer's certified pressure tests on vessels.

   b. Manufacturer's certified performance tests on operating equipment.

   c. Field pipe testing reports and certificates of approval.

   d. Welder's certificates and field test report.

   e. Field operating test results for operating equipment.

   f. Performance report on the balancing of air and water systems.

   g. Performance report and calculations for vibration isolation equipment.

   h. Manufacturer's certified reports on motorized equipment alignment and installation.

E. If submissions of catalog cuts of standard manufactured items show different types, options, finishes, performance requirements, or other variations, those features proposed shall be clearly identified.

   1. If any variations from the catalog description are proposed or required, such variations must be clearly noted on the cut.

   2. Shop drawings shall clearly indicate all details, sectional views, arrangements, working and erection dimensions, kinds and quality of materials and their finishes, and other information necessary for proper checking and for fabrication and installation of the items, and shall include all information required for making connections to other work.

   3. Shop drawings shall be numbered consecutively, and drawings related to various units comprising a proposed assembly shall be submitted simultaneously so that units may be checked individually and as an assembly.

   4. Keep on the site, in good order, a complete up-to-date set of approved shop drawings. All shop drawings shall be available for inspection by the Architect.

   5. The approval of shop drawings will be general, and shall not be construed as permitting any departure from the contract requirements other than those specifically brought to the Architect's attention and so approved.

a. If the shop drawings show any variations from contract requirements because of standard shop practices or other reasons, such variations shall be clearly identified on the drawings in order that, if acceptable, suitable action may be taken for proper adjustment in other work affected thereby.

b. Failure to identify such variations will not relieve the Contractor of responsibility for executing the work in accordance with the Contract even though such shop drawings have been approved and the work installed.

c. Approval shall not relieve the Contractor of responsibility for any error in details, dimensions, etc., that may exist on shop drawings nor for the furnishing of materials or work required by the Contract and not indicated on the shop drawings.

d. Approval shall not be construed as approved departure from details or instructions previously furnished by the Architect.

e. Approval with a requirement for resubmission is an approval contingent upon satisfactory resubmission within 30 days. Failure to comply shall result in a revocation of the contingent approval.

F. Shop Drawing Schedule

1. The Contractor shall submit, within 30 days of the award of his contract, a schedule of all proposed shop drawing submissions.

2. The schedule shall include the following information.

a. Item to be submitted
b. Date of submission
c. Latest date for approval
d. Manufacturers of the specified item.

3. Items not specifically listed as "approved equal" should be listed for consideration at this time.

G. Submittals will be reviewed for conformance with the contract drawings and specifications. The engineer's review stamp will be affixed to submittals. One of the following actions will be taken.

1. NO EXCEPTION - Submittal appears to comply with the contract drawings and specifications. Contractor is not relieved of responsibility to meet the requirements of the contract drawings and specifications due to errors, omissions, or conflicts with other equipment or trades.

2. EXCEPTIONS AS NOTED - Submittal appears to comply with the contract drawings and specifications except for the items noted by the engineer. Contractor is not relieved of responsibility to meet the requirements of the contract drawings and specifications due to errors, omissions, or conflicts with other equipment or trades.

3. REVISE AND RESUBMIT - In the opinion of the engineer the nature and/or quantity of exceptions is sufficient to require resubmission to demonstrate compliance. Submittals must be returned within 30 days for contingent acceptance to remain valid. Submittals will become rejected if not returned within 30 days.

4. REJECTED - Submittal does not comply with contract drawings and specifications.

1.14 LEED BUILDING SUBMITTAL REQUIREMENTS

A. The contractor and their subcontractors shall submit the LEED Building certification items listed herein. LEED Building submittals shall include the following, as applicable:

1. A completed ENVIRONMENTAL MATERIALS REPORTING FORM: Information to be provided for this form shall include:

   a. For adhesives, sealants, and paints, provide the VOC content in grams/Liter (g/L).

2. Material Safety Data Sheets, for all applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings applied on the interior of the building. Material Safety Data Sheets shall indicate the Volatile Organic Compound (VOC) content of products submitted (If an MSDS does not include a product's VOC content, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC content).

   The LEED Building Submittal information shall be assembled into one package per Specification section (or per subcontractor), and sent to the Architect for review. Incomplete or inaccurate LEED Building submittals may be used as the basis for the Architect's rejection of products or assemblies.

1.15 LEED BUILDING PERFORMANCE REQUIREMENTS

A. The contractor and their subcontractors shall comply and submit the LEED Building certification items as required to comply with LEED v. 2.0 Commercial Interiors (CI).

1.16 GUARANTEES AND SERVICES

A. All workmanship, installation materials and equipment shall be maintained and serviced for the guarantee period at no additional cost to the Owner.

B. Leave entire system installed under this Contract in perfect working order, and, without additional charge, replace any work or material which develops defects within the guarantee period, including all other work damaged as a result of such defects.

C. Non-durable, expendable items such as air filter media are not subject to replacement after the date of acceptance.

D. The guarantee period shall be extended as follows:

1. For heating systems, one year plus the time necessary to include one continuous heating season from November 1st to April 1st.

2. For air-conditioning systems, one year plus the time necessary to include one continuous cooling season from May 1st to October 1st.

E. Manufacturers' Warranties

1. The manufacturer shall warrant that the equipment which he has furnished is free from defects in material and workmanship. Obligations under this warranty shall be as follows:

a. The equipment manufacturer or supplier shall provide and pay for all labor, parts, accessories, materials, freight and other services to repair or replace any equipment or part thereof which, in the course of installation, start-up and testing is found to be defective.

b. For a period of one year from date of acceptance by the Owner, the manufacturer shall replace any defective equipment or part thereof; freight costs for return of defective parts, labor for parts replacement, and replacement of lost refrigerant, are the responsibility of the installing contractor.

c. The manufacturer shall provide an additional warranty on all refrigeration compressors under the same terms as Paragraph a, for a period of four years.

d. Tank linings - guarantee all internal metal surfaces against corrosion for ten years.

e. Performance - where equipment is specified by size, guarantee that it will have the capacity specified in the system in which it is installed.

2. The final acceptance of the equipment will be made after the manufacturer has adjusted his equipment, balanced the various systems, demonstrated that it fulfills the requirements of the drawings and specifications, and has furnished all the required certificates of inspection and approval.

1.17 SYSTEM MAINTENANCE

A. Contractor shall provide routine and preventive maintenance during the warranty period.

B. Contractor shall submit to Engineer for approval a comprehensive plan covering items to be maintained and service to be performed. Plan shall include checklist for use by maintenance personnel.

C. Owner's representative(s) shall accompany contractors' maintenance personnel, and receive instructions on proper maintenance of equipment.

D. Maintenance performed shall include a complete check out of each piece of equipment at least twice during warranty period. The first shall occur approximately half way through the warranty period (change of season) and the second shall occur at the conclusion of the warranty period and prior to commencement of the owner's maintenance. Each system and/or piece of equipment shall be inspected, operated through its complete range of operation, and adjusted as required. This inspection shall be the same as performed at the initial start-up of the item or system. In addition, there shall be monthly maintenance inspections of each piece of equipment. During the monthly inspections, equipment shall be checked for items such as dirty filters, belt wear, lubrication, unusual sounds or unusual operating conditions. Monthly inspections shall also include recording of system operating temperatures and pressures.

E. Contractor shall include all labor and material to perform the maintenance, including replaceable items such as filters and belts.

F. Maintenance on the following items shall be included:

1. Pumps
2. Fans, air handling units
3. Chillers
4. Filters
5. Temperature controls
6. Water Treatment
7. Unit and Cabinet Heaters
8. Domestic water heater
9. Fire Protection Systems (Sprinkler)

1.18 PERMITS AND CERTIFICATES

A. Prior to proceeding with any installation, prepare and submit to the proper authorities, for their approval, all required working drawings. Provide all necessary notices, obtain all permits and pay all local, state and federal taxes, fees and other costs in connection with the work.

B. The contractor shall be responsible for performing all controlled inspections required by applicable Administrative building Code.

1.19 COORDINATION DRAWINGS

A. Sheet metal shop drawings that have been coordinated with architectural and structural drawings shall be submitted to Engineer for approval. Drawings must be returned from Engineer either "No Exception" or "Exceptions as Noted" prior to being used as basis for coordination drawings. Refer to Section 233000 for sheet metal shop drawing requirements.

B. After sheet metal drawings have been revised per Engineers comments, reproducible copies shall be sent to the others trades in the following sequence for the inclusion of their work:

1. plumbing contractor
2. electrical work
3. mechanical piping
4. sprinkler piping

C. Prior to inclusion of sprinkler piping and equipment, contractor shall have submitted sprinkler plans and calculations to engineer for approval and to Rating Bureau for review.

D. After all trades have included their work on the coordination drawing and noted conflicts, all trades shall meet to resolve conflicts and agree to acceptable solutions. Each trade shall sign coordination drawings. Items not shown on coordination drawing are responsibility of omitting contractor and contractor is subject to additional costs incurred by other trades.

E. The Architect and Engineer are not part of the coordination drawing process. The Engineer will provide assistance relative to acceptability of installations.

F. Submit final signed coordination drawing to engineer. Only submit items that are different from previously approved shop drawings. Revisions shall be clearly indicated.

G. Any work fabricated or installed prior to sign off by all trades shall be removed and re-installed in conformance with coordination drawings.

H. Each contractor (mentioned above) is responsible for the coordination of his sub-contractors.

I. The overall coordination of the coordination process is the responsibility of the general contractor.

1.20 LEED BUILDING SUBMITTAL REQUIREMENTS

A. The contractor and their subcontractors shall submit the LEED Building certification items listed herein. LEED Building submittals shall include the following, as applicable:

1. A completed ENVIRONMENTAL MATERIALS REPORTING FORM: Information to be provided for this form shall include:

a. For adhesives, sealants, and paints, provide the VOC content in grams/Liter (g/L).

2. Material Safety Data Sheets, for all applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings applied on the interior of the building. Material Safety Data Sheets shall indicate the Volatile Organic Compound (VOC) content of products submitted (If an MSDS does not include a product's VOC content, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC content).

The LEED Building Submittal information shall be assembled into one package per Specification section (or per subcontractor), and sent to the Architect for review. Incomplete or inaccurate LEED Building submittals may be used as the basis for the Architect's rejection of products or assemblies.

1.21 QUALITY ASURANCE

A. LEED Building Performance Requirements:
The following criteria are required for materials and methods included in this section.

1. Adhesives or sealants used for work in this section shall meet the requirements of Section 01015: "Volatile Organic Compound (\TOC) Limits for Adhesives, Sealants, & Architectural Coatings" where applicable. Certification of these products shall be in accordance with the LEED Building Submittal Requirements of this Section.

PART 2 – DOCUMENTATION

2.01 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Furnish manufacturers operating and maintenance instructions, parts lists and sources of supply for replacements in accordance with Division 1 - General Requirements.

B. Provide the following:

1. Complete sets of final and correct shop drawings, maintenance and replacement parts manuals, and operating instructions, for equipment supplied.

2. Bind each set within a common binder. Index and organize with a table of contents, to permit quick and convenient reference.

C. Three days of instruction in operation and maintenance of equipment to Owner's maintenance force. Design a 2-week period, convenient to Owner, during which qualified personnel, including manufacturers' technicians and engineers will be available for Owner's instruction. Owner shall have the right to record the instruction sessions in video and/or audio format.

D. Master Operating Manual (submit in quadruplicate)

1. Manufacturer's mechanical and electrical equipment parts lists of all components of the systems listed on the equipment schedules, control diagrams and wiring diagrams of controllers. List shall give system

number, unit number, manufacturer's model number, and manufacturer's drawing numbers.

2. Step by step operating instructions for each system including preparation for starting, summer operation, winter operation, shutdown and draining.

3. Maintenance instructions for each type of equipment.

4. Possible breakdowns and repairs for each type of equipment.

5. List of nearest local suppliers for all equipment.

6. Manufacturer's literature describing each piece of equipment listed on the equipment schedules, control diagrams and wiring diagrams of controllers and a copy of the air balance report.

7. As-installed control diagrams by the control manufacturer.

8. Description of sequence operation by the control manufacturer.

9. Recommended trouble shooting procedures in the event of foreseeable mechanical system failure.

10. Complete "As-Installed" color coded wiring diagrams of all systems and all electrical motor controller connections and interlock connections of all other mechanical equipment.

11. Chart of the tag numbers, location and function of each valve.

12. Copies of the following test reports:

    a. Air Balance.
    b. Water Balance.
    c. System Performance.
    d. Required Pressure Tests.

2.02 RECORD DRAWINGS

A. Provide "Record Drawings" in accordance with Article 4 of the General Conditions Governing all Contracts, indicating in a neat and accurate manner a complete record of all revisions of the original design of the work. Include all changes and accurately record, on reproductions of the contract drawings or appropriate shop drawings and in digital format (on compact disk in Adobe Acrobat PDF and AutoCAD 2005 (minimum) ".dwg" and ".dxf" format), all deviations between the work shown on the contract documents and the work installed.

B. Submit for approval bound sets of the required drawings, manuals and operating instructions.

2.03 IDENTIFICATION MARKINGS

A. General - apply after insulation and field painting are completed.

B. Valve Identification

1. Furnish and attach to each valve a 2" diameter tag of solid brass with number and service abbreviated as noted on contract drawings. Numbers to correspond to consecutive numbers on valve chart identifying each individual valve.

2. Securely attach tags to the stem of valves with brass "S" hooks.

3. Provide valve charts mounted on 1/4" masonite and covered with heat, bonded plastic laminate. They shall identify each valve by a number, service, its functions and list any remarks concerning special features of the valve; its location and the contract drawings which reference the valve.

4. Provide one such mounted valve chart in each Mechanical Equipment Room.

5. In addition, furnish one unmounted folded copy of the valve charts for each instruction manual.

C. Piping Identification

1. Provide identification for all bare or covered piping for all services, in spaces with or without ceilings, so as to be readable from the floor (even in the case of spaces with removable and/or hard ceilings – for identification if the ceilings are later removed). Piping shall be identified by prefabricated acrylic plastic markers. Markers shall be snap on or secured with bands (6" and over). Colors and lettering shall conform to ANSI Standard 13.1-1981. Seton Name Plate Company or the approved equal. Generally they shall be located at changes of direction, take-offs, valves, where pipes pass through walls and at intervals not greater than 30'-0" on straight runs, and shall indicate direction of flow at each marker.

2. Underground piping shall be provided with underground warning tapes, buried above piping run to identify by color and text, the utility below. Non-metallic piping shall be provided with warning tape having metallic core bonded between two polyethylene films. Seton Name Plate Company or the approved equal.

D. Ductwork Identification: Provide identification for all bare or insulated ductwork for all services, so as to be readable from the floor (even in the case of spaces with removable and/or hard ceilings – for identification if the ceilings are later removed). Ductwork shall be identified by service and associated unit tag number, and direction of airflow, using prefabricated acrylic plastic markers. Markers shall be self adhesive vinyl. Seton Name Plate Company 76470 or 76471, or the approved equal. Generally they shall be located at changes of direction, take-offs, where ducts pass through walls and at intervals not greater than 30'-0" on straight runs.

E. Underground piping shall be provided with underground warning tapes, buried above piping run to identify by color and text, the utility below. Non-metallic piping shall be provided with warning tape having metallic core bonded between two polyethylene films. Seton Name Plate Company or the approved equal.

F. Equipment Identification

1. Identify all equipment listed in equipment schedules that is located in mechanical rooms, on roof, outside adjacent to building, above ceilings, and other locations that are not exposed in finished areas. Identification shall be by unit tag (per drawings), on a permanently attached minimum 1-1/2" x 3-1/2" nameplate of white core laminated bakelite with black surface and incised letters, located where it is legible and accessible. Where possible, mount plates in the same location on all similar pieces of equipment.

2. Each unit shall bear a manufacturer's nameplate with the following information:

   a. Manufacturer's name and address.
   b. Serial and model number.
   c. Rated capacity.
   d. Temperature pressure or other limitations.

3. Attach or mount adjacent to all controls and starters, a nameplate indicating which equipment it controls.

PART 3 - EXECUTION

3.01 COORDINATION AND LAYOUT

A. Study Drawings and Specifications to insure completeness of work required. Include supplementary items normal to manufacturers' requirements or standard accepted trade practices as necessary to complete work, though not specifically indicated or specified.

B. Verify measurements and conditions in field before starting work.

C. Examine materials to which work is to be applied and notify the Architect, in writing, of any conditions existing which are detrimental to proper and expeditious installation of work. Starting of work shall be construed as acceptance of conditions.

D. Confer with other trades, install work to avoid interference with other trades, and possible necessary adjustments to conform to structural conditions and work of other trades.

E. Coordinate and set inserts and locate openings in floors and walls in new construction.

1. Locate pipes and ducts to avoid interference with other work shown on the drawings and as directed by the Architect.

2. Keep all concealed pipes and ducts within the enclosing construction provided.

3. Arrange exposed work neatly in parallel runs and parallel with walls or structure, with uniformly spaced hangers and supports, and within the spaces assigned for each kind of work.

F. Make coordinated layouts showing concrete work required for housekeeping pads, equipment bases and inertia masses which are cast in place, including the location of anchors and dowels.

1. Coordinate the scheduling and placing of the concrete to suit the mechanical work schedules.

2. Concrete housekeeping pads are to cover the full area of each piece of equipment.

3. Concrete bases are to be of dimension and heights to suit the equipment.

4. The forming and placing of concrete will be provided under this specification section.

3.02 MAINTENANCE OF EQUIPMENT AND SYSTEM PRIOR TO FINAL ACCEPTANCE

A. Maintain all equipment and systems installed until final acceptance by the Architect and the Owner, and take such measures as necessary to insure adequate protection of all equipment and materials during delivery, storage, installation and shut-down conditions.

B. This responsibility shall include all provisions required to meet the conditions incidental to the delays pending final test of systems and equipment.

C. After installation of systems has been completed, operate the system to determine the capability of the equipment and controls to conform to the requirements of the drawings and specifications prior to performance testing.

3.03 EQUIPMENT INSTALLATION

A. Locate and set equipment anchor bolts, dowels and aligning devices for all equipment requiring them. Refer to concrete work coordination. Level the equipment and grout solid between the equipment and the surface below. Grout to be premixed Embeco or Five Star Grout mixed in accordance with manufacturer's specifications.

B. The field assembly, installation and alignment of equipment is to be done under field supervision provided by the manufacturer or with inspections, adjustments and approval by the manufacturer.

C. Equipment startup: Each manufacturer of equipment shall provide qualified personnel to inspect and approve equipment and to supervise the operating tests of the equipment.

D. Equipment and system test operation.

1. Notify the Architect in advance of beginning the equipment and system test operation.

2. Each piece of equipment shall be operated in its system as long as required to provide proper functioning.

3. Perform an operating test of each complete system for twenty-four hours continuous operation as a minimum, or as long as required to provide coordination and proper functioning of all related systems and controls.

4. The operating criteria for each test shall be determined in advance with the Architect's approval whenever seasonal conditions will not produce a full design load on any equipment or system.

5. Certify to the Owner that all equipment is functioning properly.

6. Should the apparatus fail to meet the contract requirements, adjust, repair or replace all defective or inoperative parts and again conduct the complete performance tests.

3.04 CLEANING AND ADJUSTING

A. Blow out, clean and flush each system of piping, and equipment as required to thoroughly clean the systems.

1. Clean all materials and equipment, and leave in condition ready to operate and receive succeeding finishes where required.

2. Adjust and align all equipment interconnected with couplings or belts.

a. Adjust valves of all types and operating equipment of all types to provide proper operation.

b. Remove and clean elements in all steam trap bodies.

c. Clean all strainers.

B. Lubricate equipment as recommended by the manufacturer, during temporary construction use, and provide complete lubrication just prior to acceptance.

C. Permanent equipment operated during construction shall not be abused or be used in service different from its design application.

1. Temporary disposable filters shall be used during temporary operation.

2. All expendable media, including belts used for temporary operation and similar expendable materials shall be replaced just prior to acceptance.

3. Packing boxes of equipment operated during construction must be replaced just prior to system acceptance, using materials and methods specified by the supplying manufacturer.

D. Equipment furnished with factory finishes shall be retouched and repainted as required to present a new appearance.

E. Provide and maintain protection for all of the work whether completed or in progress. Provide coverings and enclosures as required.

F. New and existing operating equipment and systems shall be clean and dust free inside and out. Concealed and unoccupied areas such as plenums, pipe and duct spaces and Equipment Rooms shall be free of rubbish and swept clean at time of acceptance.

3.05 TESTING AND BALANCING

A. Tests shall be performed in accordance with Division 1 - General Requirements, and the following.

B. Provide the services of an independent air and water balancing and testing firm which specializes in balancing and testing of heating, ventilating and air conditioning systems, and which is acceptable to the Owner. All instruments used shall be accurately calibrated and maintained in good working order. If requested, the balancing shall be conducted in the presence of the Architect/Owner.

C. Balancing shall not begin until the system has been completed and is in full working order. After completion of the balancing and testing submit copies of the results to the Architect.

D. Perform tests and make necessary adjustments to obtain the flow and distribution of air and water required to produce the operating criteria called for by the contract documents, in accordance with the latest standards of the National Environmental Balancing Bureau and the Associated Air Balance Council.

1. Occupied spaces shall be draft free upon completion.

2. Provide any necessary baffles at registers and diffusers.

3. Maintain the specified acoustical performance of the systems.

4. Mark final position of dampers and balancing valves.

E. Upon completion of the installation, test and balance all equipment and systems under field operating conditions to demonstrate its compliance with specification requirements. Submit three copies of the test report to the Architect. Refer to specification sections 230523 and 233000 for details of report requirements.

F. Should any part of the system fail to meet the contract requirements, adjust, repair or replace all defective or inoperative parts again conduct the complete performance tests.

G. The Architect and Owner shall be notified, in writing, at least 48 hours prior to scheduled test dates.

3.06 PAINTING

A. Thoroughly clean all surfaces, requiring prime painting, of rust, loose scale, oil and grease.

1. Dry surfaces before painting.

2. Do not paint controls, nameplates, or labels.

B. Paint all equipment not painted at the factory with one prime coat.

C. Provide field painting as follows:

1. All exposed iron work, including uninsulated ferrous piping and conduit system components, hangers, supports, equipment bases, and apparatus; prime coat, red lead.

2. Uninsulated ductwork and casing exposed to view and exposed galvanized surfaces of conduit and piping and of equipment prime painted at the shop: Prime coat, zinc chromate for galvanized surfaces.

3. Inside of all ductwork where visible through registers and grilles: One coat of flat black paint.

3.07 CONNECTIONS TO EQUIPMENT

A. Provide mechanical connections to equipment and fixtures requiring such connections which are supplied by Owner or under other divisions.

B. Provide unions, nipples, adapters, valves, flexible connections, and other trim required for final connections for each such fixture or item of equipment, as required for complete and perfect operation.

3.08 WORKMANSHIP

A. Perform all work in a practical, neat and workmanlike manner with mechanics skilled in work, and using the best practices of the trade involved.

B. No work shall be concealed until it has been inspected and approved by the Architect.

C. Workmanship or materials not meeting with requirements of the specifications and drawings and satisfaction of the Architect shall be rejected and immediately replaced in an acceptable manner, without additional cost to the Owner.

3.09 LUBRICATION

A. All equipment furnished, installed or connected under this division, shall be inspected for proper lubrication when connected and before operation of the equipment is begun.

B. The Contractor for the work of this division will be held responsible for any damage to equipment that is operated without having been properly lubricated.

3.10 USE OF PREMISES AND CLEANING

A. Remove and dispose of all waste materials and rubbish due to all construction operations under the contract, except as otherwise noted, and keep the building free from rubbish and dirt caused by his and/or his subcontractors' employees. During the entire progress of the work, rubbish removal shall be made frequently so as to prevent any potential safety or health hazard.

B. Upon completion of the work, remove all protection, paint, putty, and other stains from all fixtures and glass and leave the premises thoroughly broom cleaned.

3.11 CUTTING, ALTERING AND PATCHING

A. Provide all cutting, chasing, drilling, altering and rough patching required for the work of this division.

1. Including the restoring of existing work cut for or damaged by installation of new work, and where present work is removed.

2. All materials and workmanship required in connection with cutting, altering and rough patching shall match the existing work in every respect.

B. Do all shoring, bracing, cutting, patching, piecing out, filling in, repairing and refinishing of all present work as made necessary by the alteration and the installation of new work.

C. All holes and openings occurring in the existing floors after equipment, partitions, floors, steel work, conduits and pipes are removed or installed shall be closed up with materials similar to the adjacent work.

D. The size and location of items requiring an opening, chase or other provisions to receive it shall be given by the trade requiring same in ample time to avoid undue cutting of any new work to be installed. These provisions shall not relieve the

Contractor from keeping informed as to the required opening, chases, etc., nor from responsibility for the correctness thereof, nor for cutting and repairing after the new work is in place.

E. Include all cutting, repairing and patching in connection with the work that may be required to make the several parts come together properly and fit it to receive or be received by the work of other trades, as shown on the drawings and/or specified, or reasonably implied by the drawings and specifications.

F. All repairing, patching, piecing-out, filling-in, restoring and refinishing shall be neatly done by mechanics skilled in their trade to leave same in condition satisfactory to the Owner.

G. Materials and their methods of application for patching shall comply with applicable requirements of the specifications. Materials and workmanship not covered by the specifications and items of work exposed to view adjoining existing work to remain shall conform to similar materials and workmanship existing in or adjacent to the spaces to be altered.

H. Cutting, repairing and patching shall include all items shown on the drawings, specified in the specifications or required by the installation of new work or the removal of existing work.

I. Remove partitions, walls, suspended ceilings, etc., as necessary to perform the required alterations or new construction work. Avoid damage to construction and finishes that are to remain.

J. Protect and be responsible for the existing building, facilities and improvements. Any disturbance or damage to the work, the existing building, and improvements, or any impairments of facilities resulting from the construction operations, shall be promptly rectified, with the disturbed, damaged, or impaired work, restored, repaired or replaced at no extra cost.

K. All alterations which are not indicated on the drawings nor specified herein but necessary to make good existing work disturbed by reason of the work shall be restored to a condition satisfactory to the Owner.

L. All holes in masonry floors and walls are to be core drilled.

M. Disturbed concrete and/or cement floor areas shall be patched with approved type latex mortar. When cement mortar is used for patching, the surfaces shall be depressed a minimum depth of 1".

N. Reinstall all weather protection work in waterproof manner.

O. Openings in roofs. Openings in roofs shall be kept properly plugged and caulked at all times, except when being worked on, to preclude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed.

P. Temporary openings. All temporary openings cut in walls, floors or ceilings for pipe or ductwork shall be closed off with non-combustible fiber cement boards containing no asbestos or other hazardous material, except when mechanics are actually working at the particular opening.

3.12 TEMPORARY HEAT

A. Provide all labor, fuels, materials, tools, appliances and equipment and perform all operations necessary to maintain sufficient temporary heat to insure uninterrupted progress in the work and to protect all work and materials against injury from dampness and cold until issuance of the Architect's Final Certificate. In addition to the foregoing, the contractor shall provide temporary heat to the extent itemized below, but not limited to the following:

1. During the placing, setting and curing of all concrete, an ambient temperature of 50 degrees F shall be maintained in the areas involved.

2. During the placing, setting and/or curing of interior masonry, metal furring, plaster, tile; and taping and spackling of drywall an ambient temperature of 60 degrees F shall be maintained in the space involved.

3. In spaces where resilient floor coverings are stored an ambient temperature of 70 degrees F shall be maintained, and such temperature shall be maintained 48 hours before, during and 48 hours after installation in each space where such covering is required.

4. Except as noted above, all areas in which work is in progress, shall be maintained at 45 degrees F during working hours.

B. The building will be considered in an enclosed condition when roofing and exterior walls are in place and openings in exterior walls and roof have been provided with temporary or permanent closures.

C. The medium and procedure of providing temporary heat at all times shall be subject to the approval of the Owner and Architect.

D. Prior to the building being in an enclosed condition, temporary heat may be provided by approved type of heating and devices complete with covers, vents and/or smoke connections to the outer air so that all human hazards may be eliminated and the surfaces of the buildings protected against damage by deleterious substances resulting from the heating operations.

E. Only heaters employing tanked gas will be permitted. The use of oil or coke as fuels will not be permitted. Provide thermal protection under heating units and pails of sand adjacent thereto.

F. Prior to starting the metal lathing, or drywall spackling, the work shall be sufficiently advanced for the building to be enclosed and for temporary heat to be produced by the permanent heating system.

G. After the building is enclosed and the permanent heating system or portion of the system is substantially complete and acceptable to the Owner for temporary heating use, the contractor may, at the Owner's discretion, be permitted to use such heating facilities for temporary heat.

H. The contractor in using the permanent heating system for temporary heating agrees to the following:

1. After the Architect and the Owner approve and accept the project heating system, or portion thereof, for temporary heating purposes, the heating system shall be turned over to the contractor. When the contractor has no further need for temporary heat, the heating system shall be returned to the Owner.

2. The contractor shall assume the cost of the fuel, the cost of other operating supplies used for temporary heating and the costs involved in the operation and maintenance of the temporary wiring and electricity. If the adaption of the temporary heating system to the contractor's temporary heating needs makes necessary the installation of temporary control valves, gauges, or piping, or the installation of temporary radiation units, the contractor shall bear the costs of such adaptations.

3. That portion of the project's heating system and other related mechanical equipment termed the temporary heating system shall be limited to equipment and the necessary piping, traps, valves, strainers, controls, pumps, starters, wiring and all other apparatus and equipment necessary to cause the temporary heating system to function correctly.

I. The cost of maintenance of the temporary heating system for temporary heating is the responsibility of the contractor.

J. Permanent duct work and air handling systems may not be utilized for temporary heat. The permanent boilers and piping systems may not be utilized for temporary heating without the operation of the permanent water treatment system.

K. These provisions for temporary heating do not alter the requirements of the "General and Supplementary General Conditions" with respect to "Guarantees" and/or any "General Guaranty" contained herein.

3.13 TEMPORARY COOLING

A. Provide all labor, materials, tools, appliances and equipment and perform all operations necessary, once the building is in an enclosed and insulated condition, to maintain sufficient temporary cooling to insure uninterrupted progress in the work and to protect all work and materials against injury from dampness and heat until issuance of the Architect's Final Certificate. In addition to the foregoing, the contractor shall provide temporary cooling to the extent itemized below, but not limited to the following:

1. In spaces where millwork and/or cabinetry will be stored and/or installed, a maximum ambient temperature of 78 degrees F and maximum relative humidity of 60% shall be maintained, and such conditions shall be maintained 48 hours before installation, and continuously after installation in each space where such installation has occurred or where millwork and/or cabinetry items are stored.

2. In spaces where electronic equipment will be installed, maximum ambient temperature of 78 degrees F and maximum relative humidity of 60% shall be maintained, and such conditions shall be during installation, and continuously after installation in each space where such installation has occurred.

B. The building will be considered in an enclosed condition when roofing and exterior walls are in place and openings in exterior walls and roof have been provided with temporary or permanent closures.

C. The medium and procedure of providing temporary cooling at all times shall be subject to the approval of the Owner and Architect.

D. Prior to the building being in an enclosed condition, temporary cooling will not be required.

E. After the building is enclosed and the permanent cooling system or portion of the system is substantially complete and acceptable to the Owner for temporary cooling use, the contractor may, at the Owner's discretion, be permitted to use such cooling facilities for temporary cooling. Prior to such permanent cooling system components being used, all permanent overcurrent protection, conduit, wiring and controls shall be in place to protect the equipment and personnel. All piping pressure tests shall be performed prior to use of piping systems for temporary cooling purposes. Temporary cooling equipment shall be provided with overcurrent protection as required, coordinated with the various other contractors.

F. The contractor in using the permanent cooling system for temporary cooling agrees to the following:

1. After the Architect and the Owner approve and accept the project cooling system, or portion thereof, for temporary cooling purposes, the cooling system shall be turned over to the contractor. When the contractor has no further need for temporary cooling, the cooling system shall be returned to the Owner, after having been serviced and any normal maintenance having been performed.

2. The contractor shall assume the cost of the electricity and/or fuel, the cost of other operating supplies used for temporary cooling and the costs involved in the operation and maintenance of the temporary wiring and electricity. If the adaption of the temporary cooling system to the contractor's temporary cooling needs makes necessary the installation of temporary control valves, gauges, or piping, or the installation of temporary cooling units, the contractor shall bear the costs of such adaptations.

3. That portion of the project's cooling system and other related mechanical equipment termed the temporary cooling system shall be limited to equipment and the necessary chiller(s), cooling tower(s), heat exchanger(s), piping, valves, insulation, water treatment systems(s), strainers, controls, pumps, starters, permanent wiring, permanent overcurrrent protection, permanent controls and all other apparatus and equipment necessary to cause the temporary cooling system to function correctly.

G. The cost of maintenance of the temporary cooling system for temporary cooling is the responsibility of the contractor. The contractor shall provide the Owner with a written summary of all maintenance, repairs, and service performed.

H. Permanent duct work and air handling systems may not be utilized for temporary cooling. The permanent chiller(s), cooling tower(s) and piping systems may not be utilized for temporary cooling without the operation of the permanent water treatment system.

I. These provisions for temporary cooling do not alter the requirements of the "General and Supplementary General Conditions" with respect to "Guarantees" and/or any "General Guaranty" contained herein.

3.14 PENETRATIONS THROUGH FIRE SEPARATIONS

A. Pack annular space between sleeve and pipe (insulation) and/or conduit in fire rated construction with fire retardant putty, sealant and/or caulk. Material shall be

non asbestos based and installed in accordance with manufacturers instructions for fire rating required.

B. Penetrations of multiple items and penetrations with annular space greater than 1/2" shall be provided with approved backing material in accordance with manufacturers instructions.

C. Fire retardant sealer and system shall meet ASTM E-84, ASTM E-814, and UL-1479.

D.

MANUFACTURER	MODEL
Dow Corning	Firestop 2001
Nelson	CLK,FSP
Standard Oil	Fyre Putty
3M	CP-25

3.15 SEISMIC RESTRAINT INTERNATIONAL BUILDING CODE 2009

A. Provide seismic restraint of all mechanical, electrical, plumbing and fire protection systems as required per IBC Code 2009 Sections 1621 and referenced sections and publications.

1. If building is of Seismic Design Category A: All non-structural components are exempt from the seismic requirements of ASCE 7-05 Chapter 13.

2. If building is of Seismic Design Category B: All mechanical and electrical components are exempt from the seismic requirements of ASCE 7-05 Chapter 13.

3. If building is of Seismic Design Category C: All mechanical and electrical components with an Ip (importance factor) =1.0 are exempt from the seismic requirements of ASCE 7-05 Chapter 13. All mechanical and electrical components and an Ip = 1.5 must meet the seismic requirements for ASCE 7-05 Chapter 13.

4. If building is of Seismic Design Category D,E and F: All mechanical and electrical components must meet the seismic requirements of ASCE 7-05 chapter 13.

B. Seismic restraint calculations shall be provided for all connections of components to the structure. Calculations must be stamped by a registered professional engineer with at least five years' experience in seismic design experience, licensed in the State of North Carolina**.**

C. Analysis must indicate calculated dead loads, seismic static loads, capacity of materials utilized for connection to equipment and structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/ or welded length. All seismic restraint devices shall be designed to accept without failure, the lateral forces acting through the center of gravity.

3.16 SEISMIC BRACING

A. Prepare and make the submissions listed in accordance with the procedure specified in this Section. Contractor shall provide complete sealed seismic calculations performed by an engineer currently licensed by the State of North Carolina. This shall include all seismic calculations for piping, ductwork and equipment required to be seismically braced to comply with seismic requirements of the applicable Codes.

3.17 HURRICANE ZONE CONSTRUCTION

A. Installation of HVAC equipment shall be in compliance with the requirements of Chapter 16 of 2009 International Building Code and Chapter 7 of 2005 American Society of Civil Engineers. Contractor shall provide complete sealed wind load calculations performed by an engineer currently licensed by the State of North Carolina.

B. The HVAC installation shall be in compliance but not limited to the following measures:

1. Exposed ductwork installation on the roof is not acceptable.

2. Vibration Isolation specified in Section 230548 must provide uplift resistance.

3. The roof fans should be anchored to the curbs with at least two screws at each side and the cowlings shall be attached to the curb with four (4) 3/8 SS cables.

4. The base of the condensing units shall be anchored to the equipment stand and the stand shall be anchored to the roof. Wrap the units with at least 2 SS straps attached to the base with at least two screws or bolts at each end.

5. Roof-mounted equipment that uses latched access panels in lieu of hinges shall have hasps or other locking devices approved by equipment manufacturer.

END OF SECTION 23 00 00

SECTION 230513

MOTORS AND STARTERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the Contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. The installation and equipment is to conform to applicable building code articles and applicable reference standards cited therein.

1.03 SUBMITTALS

A. Procedure

B. Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

C. Shop Drawings

1. Submit motors with individual items of driven equipment.
2. Starters - Technical specs and application data.
3. Schedule of starters including starter model, equipment served, starter enclosure, and accessories.
4. Submit starter and drive unit wiring diagrams with the automatic control shop drawing submission required under Section 230000.
5. Variable speed drive units - Technical specs and application data.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

1.05 GENERAL REQUIREMENTS

A. Provide all necessary contacts, relays and switches for motor operation in accordance with the control system sequences and safety device operation.

B. All motors, starters, push buttons, signal devices and motor controller equipment shall be NEMA standard and UL listed.

C. All motors shall be covered by the warranty provided by the original equipment manufacturer which shall extend the full extent of the project warrantee. No motor shall be installed which has been manufactured more than two years prior to delivery.

PART 2 - PRODUCTS

2.01 MOTORS

A. All motors shall be general purpose squirrel-cage induction type, NEMA Design B, Class B insulation, continuous duty, 40 ^{o}C ambient, single or multiple speed as scheduled.

B. All three phase motors shall be NEMA Premium Efficiency design. Motor efficiency shall be indicated on the motor nameplate by the manufacturer per IEEE Standard 112 Method B in accordance with following tables:

Open Drip Proof (ODP)			
Motor	Speed (RPM)		
Size (HP)	1200	1800	3600
	NEMA Normal Efficiency		
1	82.5		77.0
1.5	86.5	86.5	84.0
2	87.5	86.5	85.5
3	88.5	89.5	85.5
5	89.5	89.5	86.5
7.5	90.2	91.0	88.5
10	91.7	91.7	89.5
15	91.7	93.0	90.2
20	92.4	93.0	91.0
25	93.0	93.6	91.7
30	93.6	94.1	91.7
40	94.1	94.1	92.4
50	94.1	94.5	93.0
60	94.5	95.0	93.6
75	94.5	95.0	93.6

Totally Enclosed Fan Cooled (TEFC)			
Motor	Speed (RPM)		
Size (HP)	1200	1800	3600
	NEMA Normal Efficiency		
1	82.5	85.5	77.0
1.5	87.5	86.5	84.0
2	88.5	86.5	85.5
3	89.5	89.5	86.5
5	89.5	89.5	88.5
7.5	91.0	91.7	89.5
10	91.0	91.7	90.2
15	91.7	92.4	91.0
20	91.7	93.0	91.0
25	93.0	93.6	91.7
30	93.0	93.6	91.7
40	94.1	94.1	92.4
50	94.1	94.5	93.0
60	94.5	95.0	93.6
75	94.5	95.4	93.6

C. Unless otherwise indicated, motors 1/2 horsepower and larger shall be three-phase; motors less than 1/2 horsepower shall be single phase. Motor voltage shall be as indicated; verify with Division 26.

D. All motors shall have a 1.15 minimum service factor.

E. Two speed motors shall be two winding type, RPM as noted on plans.

F. Single speed motors shall operate at 1750 RPM unless otherwise indicated.

G. Motors controlled by Variable Frequency Drive (VFD) units shall be rated for inverter duty (NEMA MG1, Part 31).

H. All motors shall have a terminal box, appropriate mounting base, and a ground post for connection of a ground conductor.

I. Motor enclosures shall be open drip-proof unless otherwise indicated or required.

J. Motor manufacturers:

1. General Electric Co.
2. Baldor
3. Westinghouse
4. Marathon

2.02 MANUAL STARTERS

A. Provide manual starters for single-phase motors that are not interlocked with other equipment.

B. Starter shall include quick make-quick break toggle mechanism in a suitable enclosure. The overload relay shall be field adjustable to +/-10% of nominal rating.

C.

Manufacturer	Series
Cutler Hammer	9101
General Electric	CR101
Siemens	SMF
Square D	Class 2510 Type F
Westinghouse	MS

2.03 MAGNETIC STARTERS

A. Provide electrically-held magnetic starter for three-phase motors 1/2 horsepower and larger. Magnetic starters shall be combination type, with adjustable motor

circuit protector, across-the-line contactor, and thermal overload relay in a common enclosure.

B. The motor circuit protector shall trip instantaneously when the motor current level is in excess of the trip setting. Trip settings of all poles shall be adjusted simultaneously by a single trip point adjustment.

C. The starter shall be suitable for connection to a power system having available fault current of 100,000 RMS symmetrical amperes.

D. Furnish contactors with one N.O. auxiliary interlock contact for the holding circuit, and a minimum of two additional auxiliary contacts. Coordinate auxiliary contacts with Section 230923.

E.

Manufacturer	Series
General Electric	CR387
Square D	Class 8539
Westinghouse	Class A206

2.04 REDUCED VOLTAGE STARTER

A. Provide autotransformer type starters of the closed transition type, in an enclosure, with integral motor circuit protector, for all starters of NEMA Size 4 and larger (i.e. > 25 hp at 208 volts or > 50 hp at 480 volts).

B. Transformers shall have three starting taps, 50%, 65% and 80%. Unit shall be set at 65% at factory.

C. Furnish contactors with one N.O. auxiliary interlock contact for the holding circuit, and a minimum of two additional auxiliary contacts. Coordinate auxiliary contacts with Section 230923.

Manufacturer	Series
General Electric	CR331
Square D	Class 8606
Westinghouse	A606

2.05 STARTER ACCESSORIES

A. Enclosure shall be NEMA 1 for dry location, NEMA 4 for wet or outdoor locations.

B. The disconnect handle shall be capable of being padlocked in the open position.

C. Provide all starters unless otherwise specified with manual reset thermal type overload relays having inverse time delay characteristics and interchangeable heater elements.

D. Provide each starter with a red running light, neon type, mounted through cover.

E. Provide each starter with a three position, maintained contact, H-O-A selector switch, mounted through the cover.

F. Provide two speed starters for all motors listed with multiple speeds in the equipment schedules. Multiple speed starters shall be provided with a time delay relay when switching to a lower speed.

G. Furnish contactors with one N.O. auxiliary interlock contact for the holding circuit, and a minimum of two additional auxiliary contacts for each motor speed. Coordinate auxiliary contacts with Section 230923.

H. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.

2.06 VARIABLE FREQUENCY DRIVES

A. General

1. Where variable speed control is indicated in drawings, schedules, or specifications, provide complete factory-assembled and -tested adjustable frequency AC drives as herein specified.

2. Variable frequency drives (VFD's) shall provide stepless speed control of standard NEMA Design B squirrel cage induction motors, without motor derating.

3. VFD's shall be variable torque design, suitable for HVAC pump, fan, and blower applications.

4. VFD's shall be tested and listed to the following standards:

   a. UL Standard 508C
   b. IEEE Standard 519-1992
   c. NEMA – ICS 7.0, AC Adjustable Speed Drives
   d. IEC 281000 Parts 1 and 2.

5. Each VFD shall be appropriately sized and rated to suit the driven load and input power characteristics.

6. VFD logic and control circuitry shall be microprocessor-based.

B. Design and Construction Features

1. Where located indoors in non-damp and non-wet environment, VFD enclosures shall be steel, ventilated NEMA 1, with hinged lockable door, suitable for wall mounting in sizes through 75 HP (at 460 VAC). Larger units shall have floor mounted, freestanding enclosures. Where located outdoors, or where VFD is mounted in damp or wet environment, provide NEMA 3R enclosures with strip heater.

2. The input section shall include a full-wave diode bridge rectifier, padlockable door-interlocked disconnect switch, input power fuses, input line reactor, and output reactor / filter for circuits longer than 75 feet.

3. The inverter section shall be sine-coded pulse-width-modulated (PWM), utilizing Insulated Gate Bipolar Transistors (IGBT's).

C. Performance Features

1. Produce rated output under the following service conditions:

   a. Rated input voltage +/- 10%.
   b. Ambient temperature 0^{o}C. to 40^{o}C.
   c. Relative humidity 0-95% non-condensing.
   d. Elevation up to 3300 feet above sea level.
   e. Input frequency 60 hertz, +/- 2 hertz.

2. Input displacement power factor - minimum 0.95 at any speed.

3. Output - 6 to 60 hertz, 0 to input volts, with adjustable volts/hertz.

4. Adjustable output current limit - to 115%.

5. Adjustable output current limit - to 115%.

6. Adjustable acceleration and deceleration rates.

7. Adjustable minimum and maximum speed limits.

8. Automatic restart after an input power loss, with adjustable time delay, if RUN command is still activated.

9. Input current THD - 5% maximum.

10. Efficiency - minimum 96% at full load, full speed.

11. Capable of a smooth start into a rotating motor (either direction).

12. Minimum 2 second power loss ride-through for logic and control power.

13. Motor noise attributable to the VFD shall be less than 3 dB above that with across-the-line operation, measured at 3 feet from the motor centerline.

14. Capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

15. Ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

16. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in NEC Table 430.250 for 3-phase alternating-current motors.

17. The VFD shall have an integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add AC line reactors.

18. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices and source transformers to be oversized per NEC 430.

19. Include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

20. Capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the

serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false under-load condition.

21. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

22. The VFD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

D. Protective Features

1. Integral I^2t electronic motor overload protection, adjustable.

2. Integral trip circuits for input power undervoltage, overvoltage, phase loss, and overcurrent.

3. Integral trip circuits for internal overtemperature, DC bus overvoltage, and internal or output circuit ground fault.

4. The VFD's shall be suitable for connection to a power system having available fault current of 100,000 RMS symmetrical amperes.

5. The VFD's shall be self-protecting against an open output circuit.

6. Provide input power line surge protection.

7. Provide user-selectable manual or automatic restart after a fault.

E. Controls and Indications

1. LED or LCD digital information display, including:

a. Output frequency, voltage, and current.
b. Input voltage, current, and KW.
c. % speed.
d. % load.

2. LED lamp or alphanumeric display indication of individual fault conditions.

3. Status indicators for POWER ON, READY, and RUN.

4. 3-position, maintained contact, Hand-Off-Auto selector switch.

5. Remote-Local speed reference selector.

6. Integral keypad for manual (local) speed control, adjustment, and programming functions.

7. Interfaces for remote safety contacts, start-stop contacts, and speed control (4-20 mA, 0-5 VDC, or 0-10 VDC, user selectable).

8. Form C (SPDT) dry contacts, wired to terminal blocks, for remote indication of RUN or FAULT.

9. Minimum of 3 programmable resonant frequency lockout bands.

F. Serial Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.

2. The BACnet connection shall be an RS485, MSTP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:

   a. Data Sharing – Read Property – B.
   b. Data Sharing – Write Property – B.
   c. Device Management – Dynamic Device Binding (Who-Is; I-AM).
   d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
   e. Device Management – Communication Control – B.

   If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.

3. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

4. The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.

5. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass valve control, chilled water valve control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO & AO commands in memory in the event the serial communications connection is lost.

G. EMI / RFI Filtering

1. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assemble to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

H. Special Features

1. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor. Overload protection and shall be provided in both drive and bypass modes.

2. Door interlocked, pad-lockable, circuit breaker that will disconnect all input power from the drive and all internally mounted options.

3. Fused VFD only disconnect (service switch). Fast acting fuses exclusive to the VFD – fast acting fuses allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs, which have no such fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted.

4. The drive / bypass shall provide single-phase motor protection in both the VFD and bypass modes.

5. The following operators shall be provided:

   a. Bypass Hand-Off-Auto
   b. Drive mode selector
   c. Bypass mode selector
   d. Bypass fault reset

6. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.

   a. Power-on (Ready)
   b. Run enable (safeties) open
   c. Drive mode select damper opening
   d. Bypass mode selected
   e. Drive running
   f. Bypass running
   g. Drive fault
   h. Bypass fault
   i. Bypass H-O-A mode
   j. Automatic transfer to bypass selected
   k. Safety open
   l. Damper opening
   m. Damper end-switch made

7. The following relay (form C) outputs from the bypass shall be provided:

   a. System started
   b. System running
   c. Bypass override enabled
   d. Drive fault
   e. Bypass fault (motor overload or underload (broken belt))
   f. Bypass H-O-A position

8. The digital inputs for the system shall accept 24V or 115VAC (selectable). The bypass shall incorporate internally sourced power supply and not require an external control power source.

9. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, or Bypass modes (not functional in Fireman's Override 2). The remote start/stop contact shall operate in VFD and bypass modes.

10. Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman's override. Two modes of operation are required.

    a. One mode forces the motor to bypass operation and overrides both the VFD and bypass H-O-A switches and forces the motor to operate across the line (test mode). The system will only respond to the digital inputs and motor protections.

    b. The second fireman's override mode remains as above, but will also defeat the overload and single-phase protection for bypass and ignore all keypad and digital inputs to the system (run until destruction).

11. The VFD shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD system (VFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

12. Class 20 or 30 (selectable) electronic motor overload protection shall be included.

13. There shall be an internal switch to select manual or automatic bypass.

14. There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication (broken belt) when in the bypass mode.

15. Output Reactor - A reactor (dv/dt filter) is to be installed between the drive and the motor if the total electric feeder distance between the two exceeds 75 feet.

I. Factory Testing and Warranty

1. Each unit shall be fully tested prior to shipment, including operation at full load for 8 hours in a 40^{o}C ambient.

2. Each unit shall be fully warranted by the manufacturer for a period of 36 months from date of shipment, including the cost of all parts, labor, and travel expenses.

J. Acceptable Manufacturers

1. Subject to compliance with requirements, provide variable frequency drives manufactured by one of the following:

a. Allen-Bradley
b. Yaskawa E7 Series
c. Asea Brown Boveri (ABB)
d. Graham / Danfoss
e. Square D

PART 3 - EXECUTION

3.01 GENERAL

A. Motors shall be supplied as part of factory assembled equipment specified in other sections.

B. All starters and variable speed drives shall be turned over to the Division 26 contractor for mounting, installation, and wiring in conformance with all applicable codes and ordinances. Starters and drives shall be located within line-of-site of the associated equipment being controlled.

C. Install overload heaters, adjust overload relays, and set motor circuit protectors in accordance with motor nameplate ratings and NEC Article 430.

D. Unless noted otherwise, starters for outdoor equipment shall be mounted attached to or adjacent to the equipment served and shall be provided with NEMA 3R enclosures with strip heaters.

3.02 MOTOR NOISE LEVEL

A. Motor drives for pumps and refrigeration machines, or other mechanical equipment having a motor installed within a mechanical room, shall operate with noise levels not exceeding 85 dBA.

B. Noise levels shall be determined in accordance with IEEE Standard #85 "Test Procedure for Air-Borne Noise Measurements on Rotating Electric Equipment".

C. Motor drives for fans, regardless of where located, or other mechanical equipment located outside mechanical equipment spaces, shall not contribute to increase the manufacturer's sound power ratings by 2 dB in any octave band.

3.03 VARIABLE FREQUENCY DRIVE START-UP

A. A factory authorized field service technician shall perform inspection of the drive installation and wiring, initial energizing and start-up, and the adjustments and programming necessary to achieve specified operation and performance.

B. The factory-authorized field service technician shall program the 3 available resonant frequency lockout bands during motor/drive start-up based on actual motor/equipment performance for each drive. Provide the necessary frequency and vibration testing instruments.

C. After successful start-up, a factory authorized representative shall provide a minimum of four (4) hours training and demonstration to Owner's personnel.

END OF SECTION 23 05 13

SECTION 23 05 23

PIPING, VALVES AND FITTINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of section 230000, General Provisions, and with the provisions of all applicable codes and laws.

1.03 SUBMITTALS

A. Procedure

1. Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop drawings

1. Piping Materials, Joints and Fittings.
2. Piping Specialties.
3. Valve Tags and Name Plates with Schedule and Location.
4. Valves.
5. Strainers.
6. Expansion tanks
7. Hot water accessories
8. Anchors and guides
9. Thermometers, gauges, complete listing with scale range and normal operating point.
10. Water balance, contractors qualification, procedures, and report format
11. Water Balance Report.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000. Produce and maintain required effect under operating criteria determined in advance by agreement with the Architect.

PART 2 – PRODUCTS

2.01 PIPING MATERIALS

A. All pipe shall be new, free from scale or rust, and of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name of symbol or manufacturer.

B. All steel piping shall be standard or extra strong weight, in conformance with the ASTM designation A-53 as manufactured by National Tube Division, Republic Steel Corp., or approved equal. Piping shall be seamless except as specified herein.

C. All brass piping shall be standard or extra heavy weight 85% red brass semi-annealed seamless-drawn, in conformance with the ASTM designation B-43, as manufactured by Anaconda, American Brass Co., Chase Brass and Copper Co., or Revere Copper and Brass, Inc.

D. All copper tubing shall be of weight as required for service specified in conformance with ASTM designation B-88-47 for types "L" and "K" tubing, as manufactured by Chase, Anaconda, Revere, or approved equal. Copper tubing shall be used as specified in the schedule. Tubing and fittings shall be thoroughly cleaned with sand cloth and treated with an approved flux before solder is applied.

E. All galvanized steel piping shall be standard or extra strong weight, as specified, in conformance with the ASTM designation A-53. Pipe shall be hot-dipped zinc-coated with prime western spelter and not wipes.

F. Generally, unless otherwise specified, joints in steel and wrought-iron piping of sizes 2 inches and under shall be screwed, and all sizes 2-1/2" inches and over shall be welded or flanged. All drain piping shall be screwed. Brass pipe shall be screwed 2 inches and smaller and flanged 2-1/2 inches and over. Copper tubing shall be silver-soldered or 95-5 solder as herein specified.

2.02 FITTINGS

A. Fittings shall be as specified under "Fitting Schedule" for various services.

B. Welding fittings shall be of the same material and schedule as the pipe to which they are welded. Welding elbows shall be long radius pattern unless clearances necessitate the use of standard radius pattern. Welding fittings shall be Tubeturn or Ladish.

Steel Welding Fittings	ASTM A-106
Wrought Iron Welding Fittings	ASTM A- 72
Malleable Iron Fittings	ASTM A-197
Cast-Iron Fittings	ASTM A-126
Brass Fittings	ASTM B- 62
Solder Fittings	ASTM B- 88

C. All fittings used at expansion loops or bends shall be extra heavy.

D. Cast-iron, malleable-iron and bronze fittings shall be of Crane Manufacture or approved equal.

E. Flanges shall be of the same weight as the fittings in each service category. All flanges shall be drilled and spot faced in conformance with fittings. Screwed and loose flanges shall be of cast iron. Welding flanges shall be of steel welding neck type, flanges on brass to be Crane No. 2104 or approved equal.

F. Flanges shall be faced and true and made up perfectly square and tight with gaskets. Bolts, nuts and gaskets shall be dipped in a mixture of graphite and oil just before installation.

G. Unions - Unions 2 inches and smaller shall be screwed. Unions 2-1/2" and larger shall be flanged. Screwed unions on steel pipe, unless otherwise specified, shall be of malleable iron with bronze ground seats suitable for 300 pounds, W.S.P. Screwed unions on brass pipe shall be brass, ground joint suitable for 300 pounds W.SP. Flanged unions shall be malleable iron, gasket type suitable for 150 pounds W.S.P. Unions shall be as manufactured by Crane, Dart or approved equal.

H. Brass pipe threads shall be cut with special brass threading dies, and the joints shall be made with lubricant. Strap wrenches, or equivalent, shall be used in making up brass pipe. Wrenches that gouge or scar the pipe will not be used.

I. Solder for each solder-type fitting shall be of 95% tin and 5% antimony or silver solder, as specified herein.

J. Fittings shall be of the eccentric reducing type unless otherwise noted, where changes of size occur in horizontal piping to provide for proper drainage or venting. Steel pipe bends shall be made of the very best grade open hearth, low carbon steel, leaving a smooth uniform exterior and interior finish. Pipe bends

shall be made with seamless steel pipe, leaving a minimum radius of not less than five (5) pipe diameters.

2.03 PIPE SCHEDULE

A. All piping materials installed under this Section shall be new and shall consist of the following materials and construction:

Service	2" and Smaller	2-1/2" and Larger
Chilled Water Hot Water Vents and Drains		
Construction:	Solder joint construction with threaded adapters as required. 95-5 Tin/Antimony solder.	Welded construction with flanged connections to valves and equipment
Piping:	Copper, Type L, hard drawn, ANSI H23.1, ASTM B88.	Black steel, schedule 40, seamless, ASTM A53, Grade A or B.
Unions:	Bronze solder ends, ground joints, ANSI B16.19 or ANSI B16.22.	Steel, Class 150, weld type, ANSI B16.5, ASTM A181, Grade 1.
Flanges:	Cast bronze, Class 150, solder type, ANSI B16.24	Steel, Class 150, weld type, ANSI B16.5, ASTM A234, Grade WPA.

Service	2" and Smaller	2-1/2" and Larger
Cooling Coil Drains Cold Water Make-Up		
Construction:	Solder joint construction with threaded adapters as required. 95-5 Tin/Antimony solder.	Solder joint construction with threaded adapters as required. 95-5 Tin/Antimony solder.
Piping:	Copper, Type L, hard drawn, ANSI H23.1, ASTM B88.	Copper, Type L, hard drawn, ANSI H23.1, ASTM B88.
Fittings:	Cast bronze or wrought copper, solder ends, ANSI B16.189 or ANSI B16.22	Cast bronze or wrought copper with solder ends, ANSI B16.19 or ANSI B16.22.

B. Flange Bolts and Nuts:

Bolts: ANSI B181, ASTM A307, Grade B, square head, course-thread series, Class 2B fit.

Nuts: ANSI B18.2.2, ASTM A307, Grade B, hexagonal, heavy series, semi-finished, course-thread series, Class 2B fit.

C. Gaskets: Flat ring 1/16-inch thick, compressed synthetic fiber with SBR binder. Garlock Style 3200, or an approved equal.

D. Welded Joints: Branch lines and changes in direction shall be made with factory weld fittings such as tees, 90 ells, 45 ells, weld-o-lets, thread-o-lets, and welding saddles. Job fabrication of fittings and stab-ins is not permitted.

2.04 JOINTS

A. Brass pipe threads shall be cut with special brass threading dies, and the joints shall be made up with lubricant. Strap wrenches or equivalent, shall be used in making up brass pipe. Wrenches which gouge or scar the pipe shall not be used.

B. Flange joints shall be faced true, packed and made up perfectly square and tight. Each flange joint shall be provided with best grades steel bolts and with hexagon nuts. Flanges shall be raised face, suitable for pressure of system in which they are installed.

2.05 PIPE HANGERS AND SUPPORTS

A. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from concrete construction, do not weaken concrete or penetrate waterproofing. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted both in the vertical and horizontal direction, as required. Hangers in contact with copper or brass pipe shall be copper plated steel or provided with felt sleeve.

B. Pipe hangers shall be of the band type for piping 2" and smaller, clevis for pipe 2 1/2" and larger except where otherwise noted. Hangers for generator exhaust and steam pipe 2" and smaller shall be of the clevis roller type and two rod roller type for pipe 2 1/2" and larger except where otherwise noted.

C. All vertical piping shall be supported by means of heavy wrought iron or steel clamps securely bolted or welded to the piping, and with end extension bearing on the building. Riser clamps shall be constructed of two flat wrought steel bar yokes formed to fit the pipe and bolted together.

D. Beam clamps - hangers supported from steel shall be center loading beam clamps for hangers supporting piping 2 inches. For piping 2-1/2 inches and larger, I beam clamps shall be forged steel. "C" clamps are not to be used.

E. Where piping is run near the floor and not hung from the ceiling construction, but is supported from the floor or in a trench, such supports shall be of pipe stanchion with base flange and adjustable top yoke with u-bolt retainer.

F. Where piping is run above the floor, and is not hung from the ceiling construction or not supported from the floor, such piping shall be supported from the wall with bracket hangers, expansion bolted or fish plated to the wall. Provide details for review by structural engineer.

G. For water piping (fluid less than 100F), provide insulated saddle with vapor barrier or pipe insulation plus protection shield with vapor barrier jacket. For steam, condensate, and hot-water heating piping 2 inches and smaller same as above. For hot-water heating piping 2-1/2 inches and larger, provide steel pipe covering protection saddles spot welded to pipe with insulation insert.

H. Piping in trenches shall rest or hang from angle iron cross supports provided by this Contractor.

I. Hanger rods shall be of galvanized steel not exceeding six (6) feet in length of the following diameters. Trim excess rod to within 1" of the support. Supplementary steel shall be provided as necessary

PIPE SIZE	ROD DIAMETER
2 inches and below	3/8 in.
2-1/2 & 3 in.	1/2 in.
4 & 5 in.	5/8 in.
6 in.	3/4 in.
8 in. and above	7/8 in.

J. Support Schedule

All hanger components of hanger assembly shall be hot dip galvanized or cadmium plated.

TYPE	GRINNELL	NATIONAL	SUPER TOLCO	CARPENTER & PATTERSON	M-CO
Band	70	110/115	2	1A	105
Clevis	260	215	1	100	401
Clevis roller	181	250	324	140	610
Two rod roller hanger	171/177	255/260	322	109	605
Riser Clamp	261	420	6	126	510
Stanchion w/Strap	259	X	311	125	721
Pipe Stand	X	X	316	138	X
Wall Bracket	199	710	30H	139	353
Insulation Shield	167	307	220	265	125
Insulation Saddle	160-165	310-340	260-265	351-357	X
Beam Clamp	133/228	680/695	62	82/287	360/361
Insert	281/282	600	309/310	108/650	355
Insert	X	555/560 561	107F/109F 109	104M/104F 143	320
Guide	255/256	120	420/421	S794	650 651
Insulated Shield	X	Pro-Shield	X	265CVB 465CVB	123 124

2.06 ANCHORS AND GUIDES

A. Anchor chair shall be fabricated of steel and welded to steel pipe for a minimum of 12" along top or bottom steel pipe centerline. Non ferrous pipe anchor chair shall be clamped to pipe at each end of chair (chair to be minimum of 12" long). Anchor chair shall be welded or bolted to steel restraining supports which are bolted to building structural steel.

B. Anchor chair shall be equal to Elcen Figure #278 for 4" and smaller pipe, and Figure #281 for pipe larger than 4".

C. Guides shall be fabricated of a split housing joined by a minimum of four bolts, and a split spider assembly of four arms joined by four bolts. Housing shall be at least three times the anticipated pipe movement. All guides for systems operating over 210^{o}F shall be a minimum of 12" long. Guide shall be welded or bolted to steel restraining supports which are bolted to building structural steel.

D. Guides shall be equal to Elcen Figure #411A, 411B, 412A, and 412B, of the approved equal of Metaflex.

E. Provide anchors and guides as indicated on plans or as required to properly restrain motion of piping without inducing undue pipe stress.

2.07 VALVES - GENERAL

A. All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for Pressure Piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified. All valves shall be of the same manufacturer, except for special applications.

B. The system shall be supplied with gate or butterfly type isolation valves as specified herein, at all branches mains and risers.

C. All valves shall be installed with the best workmanship and are to have neat appearance and be arranged so that they are easily accessible.

D. Each valve shall have the maker's name or brand, the figure or list number and the guaranteed working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification.

E. Check valves installed in the horizontal position shall be swing checks; valves installed in the vertical position shall be silent checks, except that all check valves in pump discharges shall be silent checks.

F. Provide blow-off valves at all strainers, and where shown on the drawings.

G. Provide valve operating chain on all gate and globe valves in Mechanical Equipment Rooms - 3" and larger, which are more than 6'-6" above the operating floor. Unit shall be complete with adjustable sprocket, chain and guide (Crane "Babbit" type). Provide hook to keep chain out of the way.

H. Generally, all valves are to be of the gate type, except that globe valves shall be used for throttling services and on traps, and pressure reducing and control valve by-passes. Globe valves used on by-passes shall have monel metal mountings.

I. All valves 2 inches in diameter and smaller shall be all bronze with bronze bodies. Valves 2-1/2 inches in diameter and larger shall have iron bodies with bronze mountings unless otherwise specified.

J. All flanged-end valves shall have renewable metal seat rings and discs. On gate valves these parts shall be of bronze, on all globe valves they shall be of bronze and suitable for throttling service.

K. All screwed-end globe valves shall be of the union bonnet type, non-rising stem with renewable metal seats and discs.

L. All valves shall have their bonnets back-seated to provide for packing under pressure.

M. All gate valves shall be of the solid tapered wedge type, union bonnet, rising stem.

N. All valves 5 inches in diameter and larger shall be furnished with an integral by-pass and a by-pass suitable for the operating pressure.

O. Drain valves shall be provided on tanks, receivers, risers and where they may be required or necessary, or directed for draining the lines and equipment. Drain valves or plug cocks shall be provided at the low points for proper drainage, and where required or directed cocks and valves shall be provided with threaded ends for hose connections.

P. All valves up to 2 inches in diameter shall have screw ends, 2-1/2" in diameter and over shall have flanged ends.

Q. Isolation valves shall be provided at all pumps, tanks, reducing and automatic or mechanical flow control devices, radiation, coils and heat exchangers, and at all other apparatus requiring partial drainage of the system for periodic maintenance or inspection. The isolation valves shall be so located as to permit removal and/or service of the isolated equipment without draining complete or substantial portions of the system.

Provide flanges or union(s) to permit removal of all equipment isolated as indicated above.

The flow and control diagrams **do not** indicate the complete requirement for isolation valves in the system. Manual valves are depicted in flow diagrams to show relative positions of division 230923 control devices.

2.08 VALVE SCHEDULE

A. All valves shall conform to the requirements of this Section for the services indicated and shall be provided as indicated on the Drawings.

B. Valves for hot water, chilled water, cold water (make-up), and pumped condensate piping systems shall comply with the following:

Valve Type	Manufacturer	Construction
Gate Valves 2" & smaller Class 150	Stockham B-124 Milwaukee 1169 NIBCO S-134	Bronze body, solid wedge disc, rising stem, union bonnet, threaded ends, 150 psi SWP, 300 psi WOG.
Gate Valves 2-1/2" & larger Class 125	Crane 465-1/2 Stockham G-623 Milwaukee F-2885 NIBCO F-617-0	Iron body, solid wedge disc, OS&Y, bolted bonnet, flanged ends, 125 psi SWP, 200 psi WOG.
Globe Valves 2" & smaller Class 150	Crane 7TF Stockham B-22T Milwaukee 590T NIBCO T-235-Y	Bronze body, composition steam disc, union bonnet, threaded ends, 150 psi SWP, 300 psi WOG.
PlugValves 2-1/2" & larger Class 125	DeZurik 118F	Cast iron body, eccentric acting, resilient plug facing, stainless steel bearings, nickel seat flanged ends, ANSI 125, 150 psi CWP
Swing Check Valves 2” & smaller Class 150	Crane T/S-433 Stockham B-309/319 Milwaukee 07 NIBCO 563Y	Bronze body, horizontal swing, bronze re-grinding disc, Y-pattern, threaded ends, 150 psi SWP, 300 psi WOG.
Swing Check Valves 2-1/2” & larger Class 125	Crane 373 Stockham F-931 Milwaukee F-2974 NIBCO F-918	Iron body, horizontal swing, bolted cap, flanged ends, 125 psi SWP, 200 psi WOG.
Spring Check Valves 2” & smaller Class 150	Mueller 109M-BP	Bronze body, globe type, stainless steel spring, bronze seat and disc, flanged ends.

Spring Check Valves 2-1/2" & larger Class 125	Mueller 105M-AP	Iron body, globe type, stainless steel spring, bronze seat and disc, flanged ends.
Ball Valves 2" & smaller Class 150	Watts B-6001 Apollo 70-200 Crane 9322 Stockham S-216 BRRS Milwaukee ML-123E NIBCO LD2000	Bronze body, two-piece, full port, reinforced Teflon seats, lever operated. 150 psi SWP 600 psi WOG. Stem extensions with sleeves shall be provided to suit insulation thickness, so handle is located clear of insulation.
Butterfly Valves 2-1/2" & larger Class 125	Crane 44-FXZ Stockham LD-712 Milwaukee ML-123E NIBCO LD2000	Ductile iron body, lug type, stainless steel stem aluminum-bronze disc, bronze or Nylatrin GS bushings, EPDM liner, with lever lock handle for 6 inches and smaller and weatherproof gear operators for 8 inches and larger, and memory stop on return piping valves.
Triple Duty Valves Class 125	Bell & Gossett 3DS Mueller 721	Combination balancing, shut off and check valve. Cast iron body, bronze seat and disc, rising stem, 175 psi WOG, ANSI Class 125

C. Combination Balancing/Flow Measuring Valve

1. Valves 1/2-inch to 3-inch size shall be of bronze/brass ball construction with glass and carbon filled TFE seat rings. Valves shall have differential pressure read-out ports across valve seat area. Read-out ports shall be fitted with internal EPT inserts and check valves. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves shall have memory stop feature allowing valve to be closed for service and then opened to setpoint without disturbing balance position. All valves to have calibrated nameplates to assure specific valve settings. Valves shall be designed for positive shut-off.

2. Valves shall be manufactured by Bell & Gossett, Armstrong or Griswold.

2.09 AUTOMATIC AIR VENTS

A. Furnish where shown on drawings and wherever else required, for water systems, of float type to expel air from system and prevent air binding. Provide each valve with 1/2" shut-off valve and overflow of soft copper tubing extended to spill over nearest open drain. Similar to Sarco type 13W or approved equal.

2.10 STRAINERS

A. There shall be approved strainers in the inlet connections to each valve feeder and makeup connection, each water regulating valve, and each diaphragm valve, and where else indicated on the drawings. The intention is to protect by strainers, all apparatus of an automatic character, whose proper functioning would be interfered with by dirt on the seat, or by scoring of the seat.

B. All strainers shall have cast iron, semi-steel or bronze bodies of ample strength for the pressure to which they shall be subjected, removable cylindrical or conical screens of monel or stainless steel and suitable flanges or tappings to connect with the piping they serve. They shall be of such a design as to allow blowing out of accumulated dirt, and to facilitate removal and replacement of a strainer screen, without disconnections of the main piping.

C. All strainers shall be Y-type with removable screen. Two-inch and smaller or where installed in non-ferrous piping system, screwed or flanged, bronze Sarco type BT.

1. 2-1/2" and larger in ferrous piping systems, flanged cast iron Sarco type AF-125. Brass screens for water 1/16" for 3" inclusive; 1/8" for 4" and above.

2.11 EXPANSION TANKS - DIAPHRAGM TYPE

A. Welded steel shell of size and volume indicated on equipment schedules. Tanks shall be constructed in accordance with ASME Section VIII, and shall bear the ASME stamp.

B. Diaphragm of heavy duty butyl, rated to 240^{O}F and 125 PSIG working pressure.

C. Accessories:

1-1/2" NPT system connection.
1-1/2" charging valve.
Lifting rings, welded to shell
Welded base or saddles (horizontal units).

D.

Manufacturer	Type/Series
Amtrol, Ex-Trol	AX, L
Bell & Gossett	B, D

2.12 WATER SYSTEM ACCESSORIES

A. Provide the following accessories in the water circulating systems.

1. Airtrol tank fitting.
2. Tank drain.
3. Make-up water pressure reducing valve.
4. Pressure relief valve.
5. Backflow preventer
6. Air vents - at all high points - Automatic in mechanical spaces, manual in concealed spaces.
7. Pipe line air separators.

2.13 PRESSURE GAUGES

A. Phosphorous bronze Bourdon tube type, cast aluminum 4-1/2" diameter case with blowout disc, stainless steel movement with bronze bushing brass socket and black numerals on a white face.

B. Accuracy: 1/2 or 1% of scale range.

C. Scale to be selected so that normal operating point is between 35% and 65% of full scale.

D. Each gauge to include brass petcock. Gauges on steam piping to include syphon.

E. Gauges to be installed:

1. Across water coils.
2. Across tube bundles (e.g. chiller evaporator, chiller condenser, convertors}.
3. Suction and discharge of pumps.
   (Compound gauge on fuel oil pump suction)
4. Inlet and outlet of pressure reducing valves.
5. Inlet and outlet of steam control valves.
6. Additional locations as shown on plans.

F.

Manufacturer	Series
H.O. Trerice	500X
Albert A. Weiss	UG-1
Weksler Instruments	AA1

2.14 THERMOMETER

A. Mercury filled red reading column type, 9" long, with one piece aluminum case and sealed replaceable glass element. Brass stem with union connection and adjustable angle to permit reading from any angle. Black numerals on white background.

B. Accuracy: 1% of scale range.

C. Scale to be selected so that normal operating point is between 35% and 65% of full scale.

D. Each thermometer to be installed in an extension neck brass separable socket. Extension neck length to be coordinated with insulation thickness. Socket and thermometer insertion length to be minimum of 75% pipe diameter.

E. Thermometers to be installed:

1. Supply and return of water coils (single return on multiple coil bank)
2. Supply and return of tube bundles (e.g. chiller evaporator, chiller condenser, convertors)
3. Circulating pump discharge .
4. Supply and return of water boilers.
5. Additional locations as shown on plans.

F.

Manufacturer	Series
Taylor	E
H.O. Trerice	BX
Weksler Instrument	AA5

2.15 REMOTE READING THERMOMETER

A. Mercury actuated bronze Bourdon tube type, cast aluminum 4-1/2" diameter flanged ease, stainless steel movement with bronze bushing, brass socket, and black numerals on a white face.

B. Braided capillary tube and sensing bulb shall be stainless steel and fully ambient compensated for its entire length. Sensing bulb to be installed in a extension neck brass separable socket. Extension neck length to be coordinated with insulation thickness.

C. Accuracy 1% of scale range.

D. Scale to be selected so that normal operating point is between 35% and 65% of full scale.

E. Thermometers to be installed as shown on plans.

F.

Manufacturer	Series
H.O. Trerice	M80300
U.S. Gauge Supertherm	9100.
Weksler Instruments	415A.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION - GENERAL

A. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the drawings or required to complete the installation intended by these specifications.

B. The drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions.

C. This Contractor shall inform himself from the general construction specifications and plans, of the exact dimensions of finished work and of the height of finished ceilings in all rooms where radiation, units, equipment or pipes are to be placed and arrange his work in accordance with the schedule of interior finishes, as indicated on the architectural drawings.

D. All piping shall be run perpendicular and/or parallel to floors, interior walls, etc. Piping and valves shall be grouped neatly and shall be run so as to avoid reducing headroom or passage clearance. All valves, controls and accessories concealed in furred spaces and requiring access for operation and maintenance shall be arranged to assure the use of a minimum number of access doors.

E. All pipe lines made with screwed fittings must be provided with as sufficient number of flanges or unions to make possible any taking down of the pipes without breakage of fittings.

F. All piping shall be erected so as to insure a perfect and noiseless circulation throughout the system. No bull head tees will be permitted.

G. All valves and specialties shall be so placed as to permit easy operation and access and all valves shall be packed at the completion of the work before final inspection.

H. Provide proper provisions for expansion and contraction in all portions of pipe work, and to prevent undue strains on piping or apparatus connected therewith. Provide double swings at riser transfers and other offsets wherever possible, to take up expansion. Arrange riser branches to take up motion of riser.

I. Approved bolted, gasketed, welded flanges shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions shall be used on piping 2" or less.

J. All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges so arranged that the equipment can be serviced or removed without dismantling the piping.

K. If after plant is in operation, any coils or other apparatus are stratified or air bound (by vacuum or pressure) they shall be repiped with new approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, this trade shall bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

L. Make all changes in size and direction of piping with fittings. Do not use miter fittings, face, or flush bushing, close nipples or street elbows. Provide clean outs at all changes in direction and at other locations shown in drainage piping.

M. Make all branch connections with tees, except that on steel piping forged steel "Weldolets" as manufactured by Bonney Forge may be used where the branch pipe is not larger than one half the size of the main pipe.

N. Tubing shall be erected neatly in a workmanlike manner. Bends in soft copper tubing shall be made with approved tubing benders to prevent deformation of the tubing in the bends. Approved seat-to-pipe threaded adapters shall be provided for junctions with valves and other equipment having threaded connections.

O. Vertical sections of main risers shall be constructed of pipe lengths welded together. No couplings shall be used.

P. The ends of all pipe and nipples shall be thoroughly reamed to the full inside diameter of the pipe and all burrs formed in the cutting of the pipes shall be removed.

Q. Piping shall be installed in accordance with the latest edition of the ASME Code for pressure piping, and all other applicable codes.

R. All piping shall be concealed above furred ceilings in rooms where such ceilings are provided (except where specifically indicated otherwise on the drawings), or walls or partitions, except as otherwise indicated.

S. Dissimilar piping shall be connected with dielectric connector as made by Ebco Company.

T. Piping at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment and control valves. Piping shall be supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

U. Pipe nipples - any piece of pipe 3" in length and less shall be considered a nipple. All nipples with unthreaded portion 1-1/2" and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be provided.

V. Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant will be permitted. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings. All pipe shall be reamed out after cutting to remove all burrs.

W. Pitch water piping upward one inch per 100 feet in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer.

X. Pitch drain piping l/8 inch per foot in the direction of flow.

Y. Branch connections to mains are to be made in such a manner as to prevent air trapping and permit free passage of air. To meet job conditions mains shall be set up to maintain headroom, and clear other trades.

Z. Provide air vents at all high points in water piping. Provide oversized float operated automatic air vent at high points of equipment connections and in mechanical rooms or as shown on piping details. Provide manual vents at all other locations. When installed above inaccessible ceilings, valves shall be installed remote and identified on valve tag chart.

AA. Avoid 90 degrees lift set-ups in supply lines by using 45 degree ells. Where 90 degree lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents.

BB. Pipe outlet of all air vents to an open sight drain if the vent is concealed or to within two feet of the floor within Machine Rooms.

CC. All water piping shall pitch back to low points for drainage. Low points shall be provided with 3/4 inch hose cocks.

DD. Provide drain valves at the heel of all interior main water risers. Provide drain valves at the heel of all perimeter water risers if shown on drawings. Pipe all drain valves to an indirect waste.

EE. Miscellaneous drains, vents, reliefs, and overflows from tanks, equipment, piping, relief valves, pumps, etc., shall be run to the nearest open sight drain or roof drain. Provide drain valves whenever required for complete drainage of piping including the system side of all pumps.

FF. Where pipe penetrates walls, partitions or slabs provide Schedule 40 steel sleeves with an internal diameter at least 2" larger than the outside diameter of the pipe. Set sleeves before pouring concrete or securely fasten and grout with cement. Floor sleeves shall project l" above the finished floor. Pack void between pipe and sleeve with an approved firestop material. See Section 230000.

GG. Provide escutcheons fastened to pipe and covering sleeve on all penetrations visible within occupied spaces, corridors, and mechanical equipment rooms. Escutcheons are to be chrome plated brass, Ritter No. 36A for vertical lines, Ritter No. 3A for all other piping.

HH. Cross connection of any devices, or construction which will permit backflow connections between a water distribution system and any part of the drainage system shall not be installed.

II. Provide domestic water connections from valved outlets to any equipment requiring same.

JJ. Keep piping 2'-0" outside the vertical line of unprotected electrical equipment, or provide painted, watertight gutters or pans with pipe drains.

3.02 PIPING SUPPORT

A. Piping shall not be hung from other piping or from equipment of other trades.

B. Piping installed in existing buildings (or in new buildings where additional supports are required), shall be hung from supplemental steel attached to and spanning the existing (or new, in new buildings) steel structure or with chemical adhesive anchors. Use of vertical expansion shields shall not be permitted. Where vertical support into masonry or concrete structure cannot be avoided, use supplemental steel as noted above, or use chemical adhesive anchors.

1. When attaching to existing concrete structure (or newly placed structure where additional supports are required), provide two chemical adhesive

anchors at each support point. The chemical anchors shall be separated by a minimum of 8". A 2.5x2.5x3/8 angle iron shall span the two chemical anchors. Drilling for chemical adhesive anchors must not interrupt or displace any existing rebar. Concrete insert shall be either external or internal threaded element by the chemical adhesive manufacturer.

2. When attaching to concrete rib construction, the chemical anchors shall be attached to the upper third of the rib. Do not attach to the bottom of concrete ribs.

3. Minimum chemical anchor embedment shall be 3". The two chemical adhesive anchors shall be the same diameter as the attachment rod.

4. Chemical adhesive product for solid concrete applications shall be Hilti HIT RE 500 with either internally threaded inserts or threaded rod supplied by the chemical adhesive manufacturer. Inserts to be similar to Hilti HIS. Threaded rod to be similar to Hilti HAS product.

C. Hanger rods shall not pierce ducts.

D. All piping connected to pumps and compressors within 50 feet of such equipment, and where required or directed to eliminate vibration or isolate pipe from building structure, Contractor shall supply and install spring type antivibration isolators as called for in Section 230548 of these specifications.

E. Where additional steel is required for the support of hangers, the Contractor shall furnish and install same subject to the approval of the Architect.

F. All piping running on walls shall be supported by means of hangers suspended from heavy galvanized steel angle wall brackets. No wall hooks will be permitted.

G. Lateral bracing of horizontal pipe shall be provided where required to prevent side sway or vibration. The lateral bracing shall be of a type approved by the Architect and shall be installed where directed by the Architect.

H. All horizontal copper tubing shall be supported by hangers not over 6' apart for piping 1-1/4" and smaller. Space hangers no more than 10' apart for piping 1-1/2"' and larger. All branches shall have separate hangers. Hangers shall be Clevis type (with copper bottom support for uninsulated brass pipe or copper tubing). If channel or angle iron trapeze hangers are used, the space on the hangers for uninsulated brass pipe or copper tubing shall be wrapped with lead shields to isolate tubing.

I. Hanger rods attached to concrete inserts or piping racks shall not be used to support piping in Mechanical Rooms or for the support of individual pipes weighing in excess of 20 lbs. per linear foot.

3.03 PIPING JOINTS

A. Welding

1. Joints between sections of pipe and between pipe and fittings shall be fusion welded in accordance with the recommendations of the American Welding Society. Mitering of pipe to form elbows, matching straight runs to form tees or any similar construction shall not be done.

2. All welding shall be done as outlined in the latest edition of the ASME Code for pressure piping.

3. Welding process - all welding shall be done by the oxyacetylene or electric arc welding process in accordance with the requirements set forth in welding of pipe joints of the codes for pressure piping.

4. Beveling and welding - all pipe 2-1/2 inches and larger may be purchased mill beveled or shall be machine beveled on both ends before welding. On odd lengths of pipe, beveling may be accomplished by means of the oxyacetylene cutting torch provided all paint, rust, scale and oxide are carefully removed with hammer, chisel or file and bevel left smooth and clean. Joints shall be prepared and welded to assure thorough fusion of alignment and the production of a joint that shall develop the full strength of the pipe and that shall be leakproof in service.

5. Welding tees - welding tees shall be used when specified hereinafter. Where necessary, branch connections shall be reinforced in an approved manner. For the smaller branches, where welding tees are unavailable, nozzles shall be welded to pipe. Where such nozzles are welded to the pipe, all cutting oxide which may drop inside the pipe shall be removed before welding the branch or section in place. Where branch size is one half the size of main or larger, use welding tees. Where branch size is two (2) sizes smaller than the size of main "Weldolets" or "Sockolets" may be used.

6. Welding rods - the welding rod used for welding steel and wrought iron shall be approved welding rod in accordance with ASTM SPEC. A233.

7. Welder shall be fully certified by the authorities having jurisdiction to certify welders for pressure piping.

B. Flanged Joints

1. Use matched flange faces and 1/16" thick compressed gaskets.

2. When connection to equipment with flat face flange, grind flange raised face flat and use full faced gaskets.

C. Screwed Joints

1. Do not damage fitting surface, remove burrs, apply red lead and ground graphite in linseed oil to male threads only. Do not use wicking, cord or similar materials. Clean joint thoroughly of excess jointing material.

D. Soldered Joints

1. 95-5 wire solder. Completely clean all surfaces and coat with a thin layer of flux.

E. Brazed Joints

1. Conform to ASA-B31.1 and ASTM B-260-56T in accordance with the requirements of the manufacturers of the fittings and the brazing material.

3.04 CLEANING OF PIPING

A. Plug all open ends of piping, valves and equipment except when work is being performed. Protect connections to equipment and control valves with temporary screens and flush piping with water. Remove dirt and debris collected.

B. Thoroughly clean the piping to remove all organics, rust, and all foreign matters and to prepare the system for permanent treatment.

C. Perform chemical cleaning after completing all pressure and leakage tests and thoroughly flushing the systems.

D. Use cleansing agent which will not interact with any of the materials in the systems in any way to produce corrosions, form deposits, weaken, reduce the life or in any way have a detrimental effect on any system components.

E. Fill the system with clean water and add sufficient cleaning preparation to provide a concentration adequate to perform complete cleaning. Add the cleaning preparation at a point which will assure good mixing.

F. Provide temporary containers to accommodate the foam that may form and temporary pumps to circulate the chemical solution.

G. Circulate the mixture of cleanser and water for a sufficient length of time to complete the cleaning.

H. Drain the system, flush with clean water, clean all strainers and screens and refill the system.

I. Cleaner for the new piping shall be Nalprep 330 as manufactured by the Nalco Chemical Co., or the approved equal.

J. Entire cleaning operation shall be performed by a competent water treatment service in strict accordance with the manufacturer's recommendations. Provide written certifications after the cleaning operation is complete.

3.05 TESTS

A. Tests all piping except drainage connections, including valves, fittings and joints hydrostatically at a pressure equal to at least 1-1/2 times the rated pressure, but no less than 200 psig for a minimum of four hours. Blank-off or remove all elements or equipment which may be damaged by the pressure. Open but do not back-seat valves. Inspect all joints and connections.

B. Test drainage piping hydrostatically and with smoke in accordance with the local authorities.

C. Repair all leaks, defects or damage revealed by resulting from the test and re-test the system.

D. Do not insulate or conceal piping until the system has been tested and the results approved.

E. Perform tests in the presence of the Engineer.

3.06 AIR ELIMINATION

A. The Contractor's attention is specifically directed to the problem of proper air elimination. In installing water piping systems and all equipment, the Contractor shall carefully plan the actual installation in such a manner that high points and air pockets be kept to a minimum and that they are properly vented where they are unavoidable. All air elimination devices called for on the drawings and in these specifications shall be provided and properly installed. In addition, this Contractor shall furnish and install all other air elimination devices which may be required due to job conditions. The liability of the Contractor under the guarantee provisions of the contract is intended to cover his responsibility for a proper, continuous and automatic air elimination to assure even and balanced distribution of water to all equipment.

3.07 ANCHORS

A. All anchors shall be separate and independent of all hangers and supports. Anchors shall be of heavy blacksmith construction suitable in every way for the work of this contract. Anchors shall be welded to the pipe and fastened to the structure with bolts.

B. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points; and shall be so arranged to be structurally suitable for particular location, and line loading. Submit details for approval.

3.08 WATER BALANCE

A. Balance all new water systems and those designated existing water system to the quantities shown with the following tolerances:

Pumps:	Design Flow plus 5%
Coils:	Design Flow plus 5%

B. Balance in accordance with ASHRAE, AABC, or NEBB procedures and submit all readings.

C. Water system balancing is to be performed by a professional organization, other than the installing contractor, qualified by experience and practice to perform this service. Submit evidence of qualifications, balancing procedures, and report forms for approval prior to start of work.

D. Submit three bound copies of the water balance report to the Engineer. Balance Report to include the following data for each water system:

1. Pump Designation, location, system type.
2. Manufacturer, model number, size.
3. Suction and discharge pressure readings.
4. Balancing valve position.
5. Motor manufacturer, frame, horsepower, volts, phase, hertz, and RPM.
6. Motor amps - Design versus Actual.
7. Water coil GPM, entering water temperature, leaving water temperature and pressure drop (Design versus Actual) - Balancing valve position.
8. Tube bundle GPM, entering water temperature, Leaving water temperature, and pressure drop (Design versus Actual) - Balancing valve position.
9. Steam coil entering pressure, flow rate, air quantity, entering and leaving air temperature.

END OF SECTION 23 05 23

SECTION 23 05 48

EQUIPMENT BASES AND VIBRATION CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

1.03 SUBMITTALS

A. Procedure

1. Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Vibration isolation equipment.

2. Submittal data shall include complete mounting details of each isolated piece of equipment, including static deflection, operating and free heights, and outside spring diameter.

3. Steel bases and concrete inertia bases shall be completely detailed.

4. Include clearly outlined procedures for installing and adjusting the isolators.

5. Performance report and calculations for vibration isolation equipment.

6. Manufacturers' certified reports on motorized equipment alignment and installation.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATIONS, GENERAL

A. All mechanical equipment shall be mounted in accordance with the specifications below and with the specific requirements shown in the equipment schedules. The vibration isolation manufacturer shall provide supervision to ensure proper application, installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation, the manufacturer shall make a final inspection and report. The Contractor shall submit this report to the Architect, in writing, certifying the proper performance of the installation.

B. The isolation manufacturer shall supply all unit isolators, complete rails, fan and motor bases and structural steel forms for concrete inertia blocks, where called for, and shall be responsible for the selection of all vibration eliminators and shall guarantee to meet the requirements of this specification.

C. Wherever rotational speed is mentioned as the disturbing frequency the lowest such speed in the system shall be used. All isolation devices shall be selected for uniform static deflections according to distribution of weight.

D. Vibration isolators shall be designed or treated for resistance to corrosion. Steel components shall be PVC coated, or phosphated and painted with rust-resistant enamel. Nuts, bolts and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with metal etching primer and painted with rust-resistant enamel. Isolators exposed to the weather shall have all steel parts hot-dipped galvanized. Nuts, bolts and washers may be cadmium plated. Spring components shall be cadmium plated and neoprene coated.

E. All fan units and air handling units (except fans mounted on slab on grade) shall be isolated as follows:

1.	Up to 450 RPM	75% efficiency (3-l/2" max. defl.)
2.	450 RPM to 850 RPM	90%
3.	850 RPM and Over	95%

F. Submittals shall show disturbing frequency, required efficiency, designed deflection and outside diameter of springs, when pertinent.

G. Horizontal pipe runs - all horizontal pipe runs within Mechanical Equipment Rooms and within 50 feet of final connections to all equipment having motors of 1/2 horsepower or larger, shall be isolated from building structure by means of spring hanger units designed for insertion in rods.

H. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.

I. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.

J. The ratio of lateral to vertical stiffness shall be not less than 0.9 nor greater than 1.5.

K. The theoretical vertical natural frequency for each support point based upon load per isolator and isolator stiffness shall not differ from the design objectives for the equipment as a whole by more than + 10%.

L. All neoprene mountings shall have a shore hardness of 40 to 65, after minimum aging of 20 days or corresponding oven-aging.

2.02 MOUNTINGS

A. Type A - double deflection neoprene mountings shall have a minimum static deflection of 0.35 inches. All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom so they need not be bolted to the floor. Bolt holes shall be provided for those areas where bolting is required. On equipment such as small vent sets, steel rails shall be used above the mountings to compensate for the overhang.

MANUFACTURER	TYPE
Amber Booth	RVD
Mason Industries, Inc.	ND and Rails RND
Vibration Eliminator Co.	T44 and D-Rails
Vibration Mountings	RD and DRB Rails

B. Type B - spring isolators shall be free-standing and laterally stable without any housing and complete with l/4" neoprene, acoustical friction pads between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflections, compressed spring height and solid spring height. Minimum static deflection: 1.0". Static deflection shall be selected. Required efficiency is attained throughout entire operating range.

MANUFACTURER	TYPE
Amber Booth	SW-1
Kinetics	FDS
Mason Industries, Inc.	SLF
Vibration Eliminator Co.	OSK
Vibration Mountings	Spring-Flex Series "A"

C. Type C - double neoprene in shear type within a steel housing suitable for suspension rod mounting. Minimum static deflection of 0.4"

MANUFACTURER	TYPE
Amber Booth	BRD
Kinetics	FLS
Mason Industries	HD
Vibration Eliminator Co.	3CD
Vibration Mountings	RHD

D. Type D - steel compression springs as described in paragraph above and neoprene sound absorbing element mounted in a steel housing, suitable for suspension mounting. Minimum spring static deflection of l.0".

MANUFACTURER	TYPE
Amber Booth	BSR, PBSR
Kinetics	SFH/SRH
Mason Industries	PCDNHS
Vibration Eliminator Co.	SNRC2
Vibration Mountings	RSHP

E. Type E - ribbed rubber or neoprene isolator pads loaded to 40 pounds per square inch. 1/4" thick steel baseplate. Minimum double pad with 16 gauge steel separator plate. Maximum pad loading of 50 psi; minimum pad static deflection of 0.1" when loaded.

MANUFACTURER	TYPE
Amber Booth	SP-NR
Kinetics	NPD
Mason Industries	Super W
Vibration Eliminator Co.	100 N
Vibration Mountings	SHEAR-FLEX

F. Type F - vibration isolation manufacturer shall furnish integral structural steel bases. Bases shall be in a rectangular shape except for pumps which may be tee-shaped. Pump bases for split case pumps shall include supports for suction and discharge base elbows. All perimeter members shall be equal to 1/10 longest span. Provide height saving brackets in all mounting locations. Fill base with reinforced concrete and mount on concrete sub-base. Provide a 1" minimum operating clearance below base. Minimum static deflection - 1-1/4".

MANUFACTURER	TYPE
Amber Booth	WSB-HS
Kinetics	SFB/FBB
Mason Industries	BMK/KSL
Vibration Eliminator Co.	OSK
Vibration Mountings	WFB

G. Type G - vibration isolators shall be designed or treated for resistance to corrosion. Steel components shall be PVC coated, or phosphated and painted with rust-resistant enamel. Nuts, bolts and washers may be cadmium plated. Spring components shall be cadmium plated and neoprene coated. The isolators shall have vertical and lateral stops. The springs shall be selected to provide minimum 2" deflection. The installing contractor shall provide and install steel beams of adequate size, strength and quantity to span between the isolators and to produce the necessary continuous support for the towers. Isolators shall include matched tapped holes in the top plate for fastening to equipment.

MANUFACTURER	TYPE
Amber Booth	CT
Mason Industries	SLR
Vibration Eliminator Co.	KW
Vibration Mountings	AWR

H. Type H - Seismic snubbers shall be located at each spring mounted piece of equipment. A minimum of four snubbers per piece of equipment. The snubber shall consist of interlocking steel members restrained by a shock absorbent material. The absorbent material shall be at least 3/4" thick and installed with a minimum 1/8" clearance. Snubbers shall withstand forces four (4) times the loads applied to the equipment mounts.

MANUFACTURER	TYPE
Amber Booth	ER
Mason Industries	Z-1011, 1225

I. Type I – spring isolation roof curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4"(6mm) thick. Steel springs shall be laterally stable and rest on 1/4"(6mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2"(50mm) of insulation.

MANUFACTURER	TYPE
Mason Industries	RSC

2.03 ISOLATION SCHEDULE

EQUIPMENT TYPE	ISOLATION TYPE
Chiller	B, E, H
Pumps	B, E, F, H
Floor Mounted Fans	B, E, H
Suspended Fans	D
Suspended Chilled Water Piping	D
Suspended Hot Water Piping	C
Unit heaters	C
Air Handlers (Suspended)	E, H
Air Handlers (Floor Mounted)	B, H
Air Handlers (Curb Mounted)	I
Fan Powered Terminal Boxes	C
Volume Boxes	C
Boiler Breeching	D*

*Provide isolators on the entire run.

PART 3 - EXECUTION

3.01 BASES AND SUPPORTS - GENERAL

A. Provide accurate templates showing all openings for anchor bolts, drains and other required openings and detailed installation instructions for equipment and motor bases and supports.

B. Align all equipment level throughout. Provide shims to facilitate pipe connections and leveling.

C. Position the isolation units in accordance with the load distribution. Locate isolation mounts so that the load, including the drive, is supported over or between the mounts with no overhang.

D. Construct all suspended or wall hung isolators, supports and accessories including hangers, cradles and wall brackets to sustain a load of at least five times the actual operating load.

END OF SECTION 23 05 48

SECTION 23 07 00

INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230700, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. Conform to applicable performance standards, listings or approvals of the following organizations.

1. National Fire Protection Association (NFPA)
2. Underwriters Laboratories (UL)

C. All insulating materials shall comply with the following ratings:

1.	Flamespread	-25
2.	Smoke Developed	-50
3.	Fuel Contributed	-50

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Insulating materials and jackets.
2. Insulating cements, mastics and adhesives.
3. Methods of installation.
4. Pump enclosure details.
5. Pipe shields.

6. Schedule of insulation (system, material, thickness, cover, method of installation).

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Type A - Fiberglass Insulation

1. The insulation should be sectional pipe jacketed with an embossed barrier laminate. 3.5 pound density insulation with a maximum thermal conductivity(k) of 0.29 Btu-in/hr-ft2-^{O}F and rated to 850^{O}F, composed of glass fibers bonded with a thermosetting resin. Insulation to be faced with vapor barrier of white flame resistant UL rated Kraft paper bonded to reinforced aluminum foil. Vapor barrier to have a maximum permeance of 0.02 perms.

2. Indoor Piping Pipe Size:

	1-1/2"& smaller	Over 1-1/2"	Fitting Type
Service:		Thickness (in.):	
Hot Water (<200^{o}F)	1"	2"	F
Chilled Water	1"	1-1/2"	G
Condensate Drains	1/2"	1/2"	G
Water Make-up	1/2"	1/2"	G
Chemical Treatment	1/2"	1/2"	G
Domestic Water	1"	1"	G
Horiz. Roof Drains	1"	1"	G

3. Manufacturers:

Owens-Corning, SSL II
Johns Manville - Micro-Lok HP
Knauf 1000^{o} Pipe Insulation

B. Type B – NOT USED

C. Type C - Foamglass Insulation

1. 8.5 PCF average density, 100 psi compressive strength, max K = 75 ^{O}F mean, and operating temperature -320 ^{O}F to 300 ^{O}F, rigid glass cells.

Service:	Thickness:
Outdoor Piping	
Chilled water	2”

2. Manufacturers:

Pittsburgh-Corning, Type H/L.B. Foamglas
Upjohn - Type CPR Trymer L may not meet H/LB spec's

D. Type D – NOT USED

E. Type E - Aluminum Jacketing

1. 016" aluminum jacket lock-on or slip-on type jacketing to be covered with acrylic coating on one outer surface and the baked epoxy moisture barrier on the inner surface.

2. Service:

Outdoor Piping on Type C Insulation

3. Manufacturer: Childers Products Co. - Lock-on or slip-on type.

F. Type F - Fiberglass insulation for valves/fittings/flanges (other than vapor seal insulation).

1. Molded factory-formed fibrous glass with 3.5 PCF minimum density, max. K = .3 at 200OF, mean, rated to 450OF.

2. Finish with white 0.020”, 25/50 rated PVC jacket, as manufactured by Proto LoSMOKE, Zeston (for use with Hamfab inserts) or approved equal. Fitting covers and jacketing to be precurled.

3.

Service:	Thickness:
Hot Water	Same as Piping

4. Manufacturers:

Fibrous Glass Products, Inc.
Insulcoustic Corp.
Hamfab

G. Type G - Fiberglass insulation for valves, fittings, flanges (vapor seal insulation).

1. Molded, factory-formed fibrous glass with 3.5 PCF minimum density, max. barrier adhesive and wrapped with glass mesh tape. Each fitting to be finished with two coats of Benjamin Foster 30-36 vapor seal.

2. Finish with white 0.020", 25/50 rated PVC jacket, as manufactured by Proto LoSMOKE, Zeston (for use with Hamfab inserts) or approved equal. All joints between PVC jacket and pipe covering shall be sealed with vapor barrier tape. Fitting covers and jacketing to be precurled.

3.

Service:	Thickness:
Chilled Water	Same as piping
Water Make-up	Same as piping
Domestic Water	Same as piping
Roof Drains	Same as piping

4. Manufacturers:

Fibrous Glass Products, Inc.
Insulcoustic Corp.
Hamfab

H. Type H - Blanket/wrap

1. One(1) pound density insulation with a maximum thermal conductivity(k) of 0.27Btu-in/hr-ft^2-^oF at 75^oF, composed of glass fibers bonded with a thermosetting resin. Insulation to be faced with vapor barrier of reinforced aluminum foil bonded to flame resistant UL rated Kraft paper. Vapor barrier to have a maximum permeance of 0.02 perms.

2.

Service:	Thickness:
Concealed Ductwork	
Supply Air	2"
Return Air	2"
Outside Air	2"

Exhaust Air downstream & 5' upstream of motorized damper.	2"

3. Manufacturers:

CertainTeed Soft Touch duct wrap with FSK facing.
Johns Manville Microlite XG duct wrap with FSK facing.
Knauf – Duct Wrap with FSK jacket.
Owens-Corning Fiberglass – Type 100 all service duct wrap.

I. Type I - Duct Board

1. Six(6) pound density insulation with a maximum thermal conductivity(k) of 0.23Btu-in/hr-ft^2-^{o}F at 75^{O}F, composed of glass fibers bonded with a thermosetting resin. Insulation to be faced with vapor barrier of reinforced aluminum foil bonded to flame resistant UL rated Kraft paper. Vapor barrier to have a maximum permeance of 0.02 perms.

2.

Service:	Thickness:
Exposed ductwork	
Supply Air	1-1/2"
Return Air	1-1/2"
Outside Air	1-1/2"
Exhaust Air downstream & 5' upstream of motorized damper.	1-1/2"

3. Manufacturers:

Certainteed – CertaPro Commercial Board.
Johns Manville – Spin-Glas Board
Knauf - Insulation Board

J. Type J - Fiberglass for tanks and accessories.

1. Three pounds density, 450^{O}F max. operating temperature, K Max = .3 at 200^{O}F, mean semi-rigid board fibrous glass insulation, unfaced.

2.

Service:	Thickness:
Inline air separators	1"
Irregularly shaped pipe accessories	1"
Domestic Water Storage Tank	1"
Condensate Pump Receivers	1"
Expansion Tank	1"

3. Manufacturers:

Owens-Corning, Type 703
Certainteed, Type IB
Knauf, Type elevated temperature board.
Manville, Type 814 Spin Glass

K. Type K - Pump Enclosures

1. Enclose pumps with an 18 gauge galvanized steel enclosure lined with a max. K = .3 at 75^{O}F, mean, 2" thick, 6# density rigid mineral fiber.

2. Service:

Hot Water Pumps
Chilled Water Pumps

3. Manufacturers:

Owens-Corning, Type 705
Manville, Type 817
Certainteed, Type iB600

L. Type L – NOT USED

PART 3 - EXECUTION

3.01 INSULATION - GENERAL

A. All insulating materials shall be applied only by experienced workmen, in accordance with the best covering practice. All piping, duct or equipment shall be blown out, cleaned, tested and painted prior to the application of any covering.

B. At all openings insulation, insulate edges neatly and protect with sheet metal frames.

C. All items below described in general indicate the type of covering required, however, all piping, ductwork or equipment that transmits heat or will form condensation shall be insulated.

D. Insulate all piping, valves, fittings, and accessories that are part of the piping systems specified to be insulated in specification section 230700. Insulate valves and strainers to permit removal of bonnets or baskets without damage to insulation on valve or strainer bodies.

E. Where existing insulation is damaged by requirements of the work, replace all damaged insulation to match existing insulation's thermal value.

F. All insulation at duct access doors shall be set in sheet metal double-pan construction.

G. No piping, ductwork, or equipment shall be insulated until tested and approved for tightness. All piping and ducts shall be dry when covered.

3.02 APPLICATION - PIPE INSULATION (TYPE A)

A. Vapor barrier jacket: Seal longitudinal joints with vapor barrier adhesive, transverse joints sealed with vapor barrier strips and adhesive. Ends of pipe insulation sealed off with vapor barrier adhesive at all flanges, valves and fittings, and at not more than 20 feet on continuous runs of pipe.

B. Finish for concealed pipe insulation: Secure all concealed pipe insulation with staples and vapor seal adhesive at longitudinal; standard all service jacket pasted on lap.

C. Finish for exposed pipe insulation: Multiple layers (minimum 2) of glass weave jacket lap sealed with Childers CP-30. Alternatively, finish with white 0.020", 25/50 rated PVC pre-curled and pre-cut jacket, as manufactured by Proto LoSMOKE or Zeston, covering over all service jacket. For exposed vapor seal insulation, same finish over vapor sealed all service jacket.

3.03 APPLICATION - PIPE INSULATION (TYPE C)

A. All piping shall be insulated with the proper thickness of Foamglas insulation as shown in the high-temperature thickness table. Insulation thickness shall be determined by highest operating temperature at which the piping normally operates.

B. Foamglas pipe insulation shall be applied to piping dry, in staggered joint fashion with all joints tightly butted. Stainless steel (1/2" x .015") or aluminum (1/2" wide x .020") bands shall be applied on 9" centers when using 18" length pipe covering, and 12" centers when 24" length pipe covering is used. Foamglas sections shall be fitted to eliminate voids. All voids shall be eliminated by refitting or replacing the Foamglas sections.

3.04 APPLICATION - PIPE INSULATION (TYPE E)

A. Install aluminum jacketing with a minimum 2" overlap lapped downward to shed water. Seal all joints with joint sealer mastic. Finish circumferential joints with 3/8" aluminum strapping and seals. Secure with aluminum bands on 8" centers.

3.05 APPLICATION - INSULATION AT PIPE HANGERS

A. Provide pipe hangers insulation protection saddles and shields.

B. Fill each pipe covering protection saddle with same insulation as specified for respective pipe or with suitable insulating cement.

C. Where shields are specified at hangers on piping with fibrous glass covering, provide for load bearing calcium silicate between shields and piping as follows:

1. For pipe covering without vapor barrier jacket, furnish at each shield 18" long calcium silicate section with canvas jacket continuous between shield and insulation.

2. For pipe covering with vapor barrier jacket, remove bottom half section of fibrous glass and replace with half section of calcium silicate. Make vapor barrier jacket continuous between shield and insulation.

3.06 APPLICATION - DUCT INSULATION (TYPE H)

A. Install duct wrap over clean, dry sheet metal ducts. All duct joints and seams must be sealed to prevent air leakage from the duct.

B. Duct wrap shall be cut to stretch-out dimensions. 2” piece of insulation is removed from the facing at the longitudinal and circumferential ends of the piece to form an overlap. Wrap the insulation around the perimeter of the duct with the facing out. Duct wrap shall be compressed a maximum of 25% in order to maintain thermal efficiency. Adjacent sections of insulation shall be tightly butted with the 2” overlapping. Staple seams on 6” centers.

C. Minimize compression of the insulation to assure maximum thermal performance. Longitudinal seam of the vapor barrier must be overlapped a minimum of 2".

D. All seams should be finished with appropriate pressure sensitive tape or glass fabric and mastic.

E. Pressure sensitive tapes should be a minimum 3" wide and be applied with moving pressure using an appropriate sealing tool.

F. Closure systems should have a 25/50 F.H.C. per UL 723.

G. For rectangular ducts over 18" wide, the duct wrap should be secured to the duct with mechanical fasteners spaced on 18" centers to reduce sag. Care should be taken to avoid overcompressing the insulation with the retaining washer.

H. Unfaced duct wrap should be overlapped a minimum of 2" and fastened with 4" to 6" nails or skewers spaced 4" apart, or secured with a wire or banding system.

I. Where vapor barrier performance is necessary, all seams, joints, penetrations, washers and damage to the facing should be repaired with a minimum 2" overlap of tape prior to system startup.

3.07 APPLICATION - DUCT INSULATION (TYPE I)

A. Fasten insulation in place with wed pins and washers or equivalent mechanical fastening method, as approved.

B. Seal all joints with vapor barrier adhesive to provide continuous vapor barrier.

C. All edges, corners, penetrations, and joints shall be reinforced and sealed with vapor barrier adhesive tape to provide continuous vapor barrier. Tape shall be 4" wide, of type, and applied in strict conformance with manufacturer's recommendations. Tape shall be applied over insulation support washers.

3.08 APPLICATION - TANK INSULATION (TYPE J)

A. Point joints with lagging cement prior to application of finish. Finish with two layers of 8 oz. glass mesh weave. Coat each layer of weave with vapor barrier adhesive.

B. Insulation shall be fastened with welded pins or stick clips on flat surfaces and with stainless steel bands on irregular surfaces.

3.09 APPLICATION - PUMP ENCLOSURE (TYPE K)

A. Fabricate the enclosure with a division coinciding with the pump split case so that part of the enclosure can be removed and the pump serviced and dismantled without destroying the insulation.

B. Fill voids in the interior of the insulated enclosure with scraps of fiberglass insulation.

END OF SECTION 23 07 00

SECTION 23 08 00 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The OPR and BOD documentation are included by reference for information only.

C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.

B. Refer to Division 01 Section "Submittals" for specific requirements.

C. In addition, provide the following:
1. Certificates of readiness
2. Certificates of completion of installation, prestart, and startup activities.
3. O&M manuals

4. Test reports

D. Control Drawings Submittal
   1. The control drawings shall have a key to all abbreviations.
   2. The control drawings shall contain graphic schematic depictions of the systems and each component.
   3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
   4. Provide a full points list with at least the following included for each point:
      a. Controlled system
      b. Point abbreviation
      c. Point description
      d. Display unit
      e. Control point or set point (Yes / No)
      f. Monitoring point (Yes / No)
      g. Intermediate point (Yes / No)
      h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. **Red-lined Drawings:**

1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. **Operation and Maintenance Data:**

1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
2. The CxA will review the O&M literature once for conformance to project requirements.
3. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the Contractor.

D. **Demonstration and Training:**

1. Contractor will provide demonstration and training as required by the specifications.
2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
7. Review data in O&M Manuals.

E. **Systems manual requirements:**

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The GC shall include final approved versions of the following information for the Systems Manual:
    a. As-Built System Schematics
    b. Verified Record Drawings
    c. Test Results (not otherwise included in Cx Record)
    d. Periodic Maintenance Information for computer maintenance management system
    e. Recommendations for recalibration frequency of sensors and actuators
    f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
    g. Training Records, Information on training provided, attendees list, and any on-going training

3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.

4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment only):

B. Perform commissioning tests at the direction of the CxA.

C. Attend construction phase controls coordination meetings.

D. Attend testing, adjusting, and balancing review and coordination meetings.

E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Provide information requested by the CxA for final commissioning documentation.

G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

H. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

I. Update schedule as required throughout the construction period.

J. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

K. Assist the CxA in all verification and functional performance tests.

L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

M. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.

N. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

O. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

P. Participate in, and schedule vendors and contractors to participate in the training sessions.

Q. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
1. HVAC&R equipment including all fans, air handling units, ductwork, dampers, terminals, and all other equipment furnished under this Division.
2. Building automation system.
3. Test and balance.

R. The equipment supplier shall document the performance of his equipment.

S. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

T. Test, Adjust and Balance Contractor
1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.
6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.

U. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

V. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.

3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

W. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 OWNER’S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for Owner’s Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for Design Professional’s Responsibilities.

3.5 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.6 TESTING PREPARATION

A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 TESTING, ADJUSTING AND BALANCING VERIFICATION

A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. **Equipment Testing and Acceptance Procedures**: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. **HVAC&R Instrumentation and Control System Testing:** Assist the CxA with preparation of testing plans.

C. **Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment:** Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. **Refrigeration System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. **HVAC&R Distribution System Testing**: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. ***Air Cooled Chiller***
2. ***Air Handling Unit***
3. ***Boiler***
4. ***Building Automation System (see below)***
5. ***Chemical Treatment – Hot Water Boiler***
6. ***Ductwork***
7. ***Energy Recovery Unit***
8. ***Exhaust Fan***
9. ***Hot Water System***
10. ***Piping***
11. ***Pump***
12. ***Testing, Adjusting and Balancing***
13. ***VFD***
14. ***Water Treatment***

3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.12 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

C. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

3.14 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

B. **Mechanical Contractor.** The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, heat exchangers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:

   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.

   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

   c. Discussion of relevant health and safety issues and concerns.

   d. Discussion of warranties and guarantees.

   e. Common troubleshooting problems and solutions.

   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.

   g. Discussion of any peculiarities of equipment installation or operation.

   h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-2007, is recommended.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

C. **Controls Contractor.** The controls contractor shall have the following training responsibilities:

1. Provide the CxA and AE with a training plan four weeks before the planned training.

2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and AE. Copies of audiovisuals shall be delivered to the Owner.

4. The trainings will be tailored to the needs and skill-level of the trainees.

5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

8. There shall be three (3) training sessions:

    a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.

    b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:

        1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.

        2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy

savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.

4) Every screen shall be completely discussed, allowing time for questions.

5) Use of keypad or plug-in laptop computer at the zone level.

6) Use of remote access to the system via phone lines or networks.

7) Setting up and changing an air terminal unit controller.

8) Graphics generation

9) Point database entry and modifications

10) Understanding DDC field panel operating programming (when applicable)

c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

D. **TAB.** The TAB contractor shall have the following training responsibilities:

1. TAB shall meet for 4 hours with facility staff after completion of TAB and instruct them on the following:

a. Go over the final TAB report, explaining the layout and meanings of each data type.

b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.

c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.

d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.

e. Other salient information that may be useful for facility operations, relative to TAB.

END OF SECTION 23 08 00

SECTION 23 09 23

CONTROLS AND INSTRUMENTATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

C. Provide all labor, materials, tools, equipment, and services for a complete direct digital control (DDC) system as indicated, in accordance with provisions of contract documents.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. The installation and equipment is to conform to applicable building code articles and applicable reference standards cited therein.

C. It is the responsibility of the DDC system contractor to be familiar with all codes, rules, ordinances, and regulations of the Authority Having Jurisdiction and their interpretations which are in effect at the site of the work.

D. The latest issue of applicable standards and recommended practices of the following agencies in effect shall form a part of the specification to the extent each agency's relative standards or recommended practices apply to the Systems and its components as specified herein.

1. Federal Communications Commission (FCC)
2. American National Standards Institute (ANSI)
3. American Society of Mechanical Engineers (ASME)
4. Electronic Industries Association (EIA)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA)
8. Underwriters Laboratories (UL)
9. Occupational Safety and Health Administration (OSHA)

10. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

E. The DDC system contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in these documents.

F. All systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All Systems components of a given type shall be the product of the same manufacturer.

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

Automatic control components
Sequences of operation
Starter wiring of all automatically controlled motors
Control diagrams
Color coded wiring diagrams
Control valves
Variable speed drive unit
Sample of panel graphics
Direct digital control panels
Computer program
Accessories and auxiliaries
Library of custom computer graphics to be installed under this contract.
Outline of system test and commissioning procedure and anticipated schedule for testing and commissioning using project milestones.

1.04 SYSTEM TESTING AND COMMISSIONING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

B. Control system shall be set up and checked out by factory trained competent technicians skilled in the setting and adjustment of FMS equipment used in this

project. This technician shall be experienced in the type of systems associated with this FMS.

C. At the time of final observation, demonstrate the sequence of operation for each system to the Engineer or other designated Owner's representative.

1.05 IDENTIFICATION TAGS AND DRAWINGS

A. Provide two copies of the as-installed control system, mounted on masonite and covered with heat bonded clear plastic laminate.

B. Provide identifying tags on all controls to conform to the designation of the control diagrams.

C. Provide nameplate on each starter equal to equipment identification (Section 230000) indicating equipment controlled, source of control voltage, and equipment interlocked through starter. Size of identification nameplate to be a function of information contained (minimum 1-1/2" x 3-1/2").

1.06 MANUFACTURER'S WARRANTEE

A. In addition the warranty specified in 230000, the EMS vendor shall warrant all system components for a period of two years from the date of final acceptance by the Owner and Engineer. The warranty shall include parts, labor, and debugging of system software.

1.07 TRAINING OF OWNER'S OPERATING PERSONNEL

A. In addition to the on site training specified elsewhere, the control contractor shall train two facilities personnel at the manufacturer's regional training facility.

B. The course shall be the same course used in the training of the manufacturer's own service personnel. The course shall have a minimum of 40 classroom hours, and shall cover the following curriculum.

-Programming
-Maintenance of hardware
-Trouble shooting
-Repairing and rebuilding system components

C. Furnish the cost of training additional facilities personnel during the guarantee period.

PART 2 - PRODUCTS

2.01 ELECTRIC CONTROLS

A. General

1. Electrical controls of the low voltage type, shall be minimum #18AWG THHN/THWN, plenum-rated, with copper conductors. 120 volt control wiring shall be minimum #12AWG, THHN/THWN, terminated in appropriate lugs.

2. Safety controls shall be 120 volts or less, with one leg grounded.

2.02 INDIVIDUAL INDICATING PANELS

A. Provide separate indicating panels in each mechanical room, to house all miscellaneous controls, relays, etc. serving systems located in the room. Mount controls, control setting indicator, all control pressure gauges and all remote mounted system temperature and pressure gauges on the panel.

B. Locate the panels near the central equipment for each system. The panel mounted controls for air systems may be mounted in a common panel.

C. Construct the panels of a minimum of 16 gauge steel or formica properly braced and stiffened and supported on an angle iron frame.

D. Provide a diagram of each device and its position in the panel, with nomenclature matching the final control diagrams.

2.03 MOTORIZED DAMPERS

A. Constructed multiple opposed blades of extruded aluminum 16 gauge steel crimped at the ends or of doubled 22 gauge steel, formed and spot welded for stiffness or of airfoil shaped aluminum. Limit blade width to 10". Provide steel linkage and shaft and nylon or oil impregnated bronze bearings. Set damper blades in a welded steel channel frame.

B. Galvanize or zinc plate all steel parts. Finish with aluminum paint.

C. Damper blades and frame shall have butyl or neoprene mechanically fastened to insure airtight seal when closed. Provide seals on all four sides. Seals shall be rated for operation between -40^{o}F and 200^{o}F. Maximum leakage shall not exceed 4 SCFM/FT^{2} at 3.0 inch pressure differential.

D. Damper linkage arrangement shall be equal percentage and shall match the damper operator.

Application:	Fresh Air
	Relief
	Return
	Exhaust
	Smoke Damper

2.04 DIRECT DIGITAL CONTROL SYSTEM

A. Approved manufacturers for the automatic control systems are as follows:

Manufacturers	SERIES
Alerton	
Honeywell	EXCEL 5000 w/ Symmetre software
Johnson Controls	Metasys
Siemens	Apogee
Trane	Tracer

B. System Architecture

1. The system shall employ distributed processing architecture. Interruption of the main network bus or any of the local LAN buses shall not interrupt the operation of the system in any way. DDCP shall be so organized such that all necessary inputs and output points necessary to accomplish specified sequences of operation shall be connected to the same DDC panel.

2. It shall be possible to access data from any point on the system from any other point on the system including space sensors, DDCP's, LAN controller's, etc.

3. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a single shared high speed local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

4. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

Access to system data shall not be restricted by the hardware configuration of the facility management system. The hardware configuration of the DDC system network shall be transparent to the user when accessing data or developing control programs.

5. General Network Design: Network design shall include the following provisions:

   a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.

   b. Support of any combination of controllers and Operator Workstations directly connected to the local area network.

   c. Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

   d. Message and alarm buffering to prevent information from being lost.

   e. Error detection, correction, and re-transmission to guarantee data integrity.

   f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

   g. Commonly available, multiple sourced, networking components shall be used to allow the DDC system to coexist with other networking applications. The following are acceptable technologies: ARCNET and/or ETHERNET and/or SERVICE TELEPHONE PAIRS and/or BROADBAND.

   h. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading. When a collision-based network is proposed, the Contractor shall provide detailed calculations showing worst-case network response times.

   i. Automatic synchronization of the real-time clocks in all DDC panels shall be provided.

C. Direct Digital Control Panels (DDCP)

1. Stand-alone Controllers shall be micro-processor based with a minimum word size of 16 bits. They shall also be multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2. Each DDC Controller shall have sufficient memory, a minimum of 1 megabyte, to support its own operating system and databases, including:

-Control processes
-Energy management applications
-Alarm management applications including custom alarm messages for each level alarm for each point in the system.
-Historical/trend data for points specified
-Maintenance support applications
-Custom processes
-Operator I/O
-Dial-up communications
-Manual override monitoring

3. Each DDC Controller shall support:

Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

a. Analog inputs

(1) 4-20 mA
(2) 0-10 Vdc
(3) Thermistors
(4) 1000 ohm RTDs

b. Digital inputs

(1) Dry contact closure
(2) Pulse Accumulator
(3) Voltage Sensing

Direct control of pneumatic and electronic actuators and control devices. Each DDC Controller shall be capable of providing the following control outputs without the addition of equipment outside the DDC Controller cabinet:

c. Digital outputs (contact closure)
d. Contact closure (motor starters, sizes 1-4).
e. Analog outputs

(1) 0-20 psi
(2) 4-20 mA
(3) 0-10 Vdc

4. Each DDC Controller shall have a minimum of 10 per cent spare capacity for future point connection. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

5. DDC Controllers shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

6. The operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.

a. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

b. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

7. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or

analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

8. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

9. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

10. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

    a. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.

    b. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

11. Provide a separate DDC Controller for each HVAC system as indicated by separate articles in the Part III - Execution section of this specification section. It is intended that each unique system be provided with its own point resident DDC Controller.

12. Telecommunication Capability:

    a. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator stations and/or remote terminals on an intermittent basis via telephone lines, as indicated in the sequence of operations.

    b. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events using recorded voice messages for each alarm category and system prepared by the DDC vendor in coordination with the Owner.

       DDC Controllers shall be able to store a minimum of 10 phone

numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.

The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.

c. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote DDC Controllers. The fact that communications are taking place with remote DDC Controllers over telephone lines shall be completely transparent to an operator.

An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.

A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial DDC Controllers or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.

D. Transmission Network.

1. The control system shall include a multi-drop digital transmission network that provides the communication link between the microprocessor controllers and the console. The system shall utilize a cyclic redundancy check or dual transmission with parity check to insure signal reliability.

2. The transmission network shall utilize a twisted shielded grounded pair or coax cable and shall be hereinafter called a trunk. The trunk shall have an allowable line length of at least 10,000 feet signal degradation. Trunk shall be interfaced to the system via standard IEA interface. With the addition of modems, the multi-drop trunk may interface to an unconditioned voice band 3002 telephone line for remote printer tie-in to the console.

E. Control Devices and Sensors

1. Figure numbers listed are for Landis & Gyr Powers (*Siemens Building Technologies)*. The approved equal of the other manufacturers listed are acceptable.

Space thermostat	540-121
Space/Return air humidity sensor	534-635,6
Dewpoint sensor	531-825
Outdoor air temperature sensor	544-329
Duct temperature sensor	544-339
Duct temp'sensor (averaging)	544-343
	544-345
Duct temperature sensor (TCUs)	536-811
Pipe temperature sensor	544-350
Low limit thermostat	134-1510
Control valve (electronic)	VE 339
Control valve (electronic)	*273*

Averaging type elements on all duct mounted controllers.

2. Temperature sensors - (analog input)

Room sensors shall be RTD, thermistor type electronic, or pneumatic where indicated, transduced with non-adjustable sealed casing with ventilated blank covers. Accuracy of sensors shall be +/- 1/2^{o}F through a range of 30^{o} between 50^{o} and 80^{o}F.

Each room sensor shall be capable of reporting its value at a minimum of 5 adjustable setpoints as determined by system operator as follows:

Day Summer Cooling	72^{o}F
Night Summer Cooling	78^{o}F
Day Winter Heating	68^{o}F
Normal Night Heating	65^{o}F
Low Limit Night Heating	50^{o}F

3. Pipe and duct sensors shall be RTD, thermistor type, electronic non-adjustable in sealed casings. Accuracy of sensor shall be +/- 1/2^{o}F through industry standard ranges required for service. Insertion type bulb shall be used where required for piping systems or (with duct flange) for use in non-stratified air such as return or exhaust air plenums. Furnish and supervise installation of stainless steel wells for all piping systems.

All pipe and duct sensors shall have an accessible NEMA 1 electrical box for connections and terminations.

4. Humidity sensor - analog input

Humidity sensors shall employ a bulk polymer type sensor capable of an accuracy of ±2% r.h. The sensor shall provide a linear, proportional 4-20ma output signal. The sensor operating range without loss of accuracy shall be 30 °F to 130 °F.
Room mounted sensors shall be provided with non-adjustable sealed casing with ventilated blank covers matching the temperature sensor in appearance.

All duct sensors shall have an accessible NEMA 1 electrical box for connections and terminations.

5. Flow sensors

Ultra sonic, clamp on type. The unit shall be capable of measuring flow over a range of 0.1 to 40.0 feet per second pipe velocity, with flow in either direction.

The transducers shall be NEMA 4, standard temperature metal body. The flow computer shall be a two channel type in a "blind" configuration capable of monitoring two flow stations simultaneously.

The unit shall be capable of measuring the flow within pipes over a size range of 1/2" to 24" diameter. Mounting track shall be dielectrically compatible with the pipe to which the unit is mounted.

Performance:

Liquid temperature: -40°F to 250 °F
Accuracy: ± 2%
Repeatability 1/2%
Sensitivity: 0.001 fps

The unit shall provide a 4-20 ma input signal to the DDC system.

Manufacturer: Controltron Inc.
155 Plant Avenue
Hauppauge, NY
(516) 231-3600

Model: System 990 Uniflow

6. Carbon Dioxide Sensors

Carbon dioxide sensor suitable for space mounting.

Range: 0 - 2000 PPM	
Accuracy @ 70 ^{o}F:	$\pm$ 40 PPM + 3% of reading
Operating Temp: 10 ^{o}C to 35^{o}C	
Operating Humidity:	5% to 100% r.h.
Housing: ABS plastic	
Output signal: 4-20 ma	
Power Supply: 24 VAC	

Manufacturer: Vaisala GMW-25 (Wall), GMD-20 (Duct)

7. Current Sensing Relay (CSR)

a. Provide a current sensing relay where indicated on the drawings for monitoring electrical current to operating electrical motors. Each relay shall be selected for the brake horsepower of the motor and shall provide a signal to the DDC system when the current exceeds specified parameters (locked rotor current).

b. The SCR shall be selected with extended frequency feature for the low frequency applications.

c. Features shall include variable trip point and time delay, current monitoring from 10 mA to 60 AC Amps, electrical isolation between circuits, LED trip status indicator, calibrated dial and external current transformers where applicable.

d. Provide Power-On delay: 100 ms max. Frequency 12 to 400 Hz. Mechanical life 10,000,000 operations @ rated load.

e. Manufacturer: CR Magnetics Inc., Model: CR 4395 or approved equal.

8. Current indicator: (CI)

a. Provide a current indicator at each fan motor. The current indicator shall sense voltage drop due to broken fan belt or detached fan wheel and send a signal to the DDC system.

b. The indicators shall be factory calibrated for the turn on point. The value of the turn on point shall be determined by the temperature control contractor and submitted for engineer's approval.

c. Indicators shall be fully isolated, self powered units and supplied with the LED attached to the current sensing transformer.

d. Manufacturer: CR Magnetics, Inc. Model: CR2530

F. Central Operators' Terminal.

1. A central operators' terminal shall provided for monitoring of all DDC system functions. The central operator's terminal shall be installed in a location which shall be determined in consultation with the Owner's facilities manager.

Provide a second Operators' Terminal, identical to the Central Operators Terminal, in the location defined on the drawings or as directed in field.

Provide the software necessary to permit an owner purchased notebook computer to operate as a fully capable operator's terminal.

2. Output shall be 30 character alpha numeric display in English Language which can be scrolled up to 80 characters wide per line to indicate all dynamic temperature, pressure, humidity and flow values, equipment status and alarms and alarm limit set points. This shall also display set points of all DDC loops, control pressure to controlled actuators and complete DDC control loop strategies.

3. Input and control shall be via an alpha numeric keyboard with the following commands and control initiated at the keyboards; start/stop equipment, set or change alarm limits, add, modify, enable or disable control strategies, tune-up control strategies by adjusting parameters, define and set alarm status and limits, add or delete points to system and initiate hard copy record of any data and select points to be trended over a period of time.

4. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. For example, users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

5. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

6. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in a windowing environment to speed facility operation and analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the FMS contractor shall provide at least two operator stations.

7. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

    a. Passwords shall be exactly the same for all operator devices, including DDC panel portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

    b. A minimum of five levels of access shall be supported:

    c. A minimum of 50 passwords shall be supported at each DDC panel.

    d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, shall be limited to only those items defined for the access level of the password used to log-on.

    e. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

8. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

a. Start-up or shutdown selected equipment
b. Adjust setpoints
c. Add/Modify/Delete time programming
d. Enable/Disable process execution
e. Lock/Unlock alarm reporting for each point
f. Enable/Disable Totalization for each point
g. Enable/Disable Trending for each point
h. Override PID Loop setpoints
i. Enter temporary override schedules
j. Define Holiday Schedules
k. Change time/date
l. Enter/Modify analog alarm limits
m. Enter/Modify analog warning limits
n. View limits
o. Enable/Disable Demand Limiting for each meter
p. Enable/Disable Duty Cycle for each load

9. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all points in the network
b. List all points currently in alarm
c. List of all off-line points
d. List all points currently in override status
e. List of all disabled points
f. List all points currently locked out
g. List of all items defined in a "Follow-Up" file
h. List all Weekly Schedules
i. List all Holiday Programming
j. List of Limits and Deadbands

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

10. Features:

Minimum 2.0 gHZ Intel "Pentium IV" processor.
3.5" 1.44MB floppy drive
Iomega Zip Drive
Minimum 52X CD ROM
Minimum 24x10x40 Read-Write CD ROM
Adjustable display contrast.
Typewriter keyboard with quick entry numeric pad.
ASCII character set.
(2) USB, (1) Serial, (1) parallel, and mouse ports.
17" SVGA (1024X768) Monitor
512 KB Static RAM
Integral surge suppressor AC power supply
Latest Windows operating system
Latest Version of Microsoft Office Professional

11. Ratings:

Temperature 50^{o}F - 150^{o}F
Humidity to 98% R.H.

12. Accessories:

- Minimum 60 gigabyte hard disk including an allowance of at least 40 gigabytes for storage of archived trend logged data and other owner provide software."
- Operators "mouse" with pad
- Modem
- UPS (Uninterruptible Power Supply)
- Library of interactive computer graphics, prepared by the DDC vendor, of HVAC system arrangements similar to those depicted on mechanical flow and control diagrams; Insight package for PC's.
- Archiving software package capable of downloading data to the hard drive in ASCII format and/or downloading data to Microsoft Excel.
- System 600 management applications library
- System 600 Dial-Up software
- System 600 Maintenance Management for Insight
- Remote monochrome video terminal for additional monitoring locations.

G. Terminal Control Unit

1. Control of terminal units shall be accomplished by a microprocessor based stand alone controller utilizing Direct Digital Control. The Terminal Control Unit shall interface to the building control system in a multi-drop communications network originating at the control system field panel. An individual controller shall be provided for each terminal unit.

   Each Terminal Control Unit shall contain resident programs which are field selectable for a specific application. All resident programs shall be contained in non-volatile memory using EEPROM, EPROM, and PROM. Systems that employ volatile (RAM) memory shall provide 72 hour battery back-up for each Terminal Control Unit.

2. Each Terminal Control Unit shall be accessible for purposes of control and monitoring from central or remote operator's terminals as specified herein.

3. The Terminal Control Unit shall continue its primary control function independent of other network communication. Reversion to a failed (normally open or normally closed contact position) mode on separation from the communication bus is not acceptable.

4. An operator's terminal connected to any field panel on the network, directly or via modem, will have access to all Terminal Control Units connected to all communication bus. Under no circumstances will it be necessary to identify the specific bus, field panel, or Terminal Control Unit prior to obtaining values or status for any point in the building system.

H. Printer

1. A wide carriage high-speed keyboard/printer shall be provided for hard copy data and alarm printouts. The minimum print speed shall be 160 characters per second. The printer shall have a line length of at least 132 characters and the character set shall be the standard 96 character ASCII upper class and lower case character set.

   The printer shall be equipped with a compressed mode option for 220 characters per line. The printer shall have both 9 x 9 DOT matrix character structure and 9 x 18 DOT matrix for letter quality output.

   Accessories:

   -Adjustable line spacing of 6 or 8 lines per inch.
   -Adjustable tractor for 5 to 15 inch paper widths.
   -Software selectable emphasized, double strike, and double width character capability.

I. Man-Machine Interfacing.

1. The following functions shall be capable through the operators' terminal or printer/keyboard.

-Add, delete, or change points without vendor assistance.
-Write custom control sequences without vendor assistance.
-Time of day scheduling.
-Start/stop time optimization.
-Night setback.
-Economizer cycle.
-Holiday schedule.
-Run time totalization.
-Trending.
-Duct cycle program.

2. Operator shall be able to interface with the system in English Language as follows:

-Display.
-Command.
-Edit.
-Add.
-Modify.
-Copy.
-Delete.

3. Output information shall be displayed or printed for hard copy record and shall include:

-6 alpha/numeric character for point names.
-12 alpha/numeric characters for point descriptors.
-Appropriate alpha/numeric characters for values such as temperature, pressure and humidity.
-Appropriate alpha/numeric characters for status and alarms.

Example: "EC-1 Ret Air Temp 78.5^{o}F Hi Alarm"

All points may be displayed or printed including:

All values, may be shown to nearest 1/10.
All motors, may be commanded and shown on/off or automatic.
All alarms shall have condition to be displayed or printed.
All control point adjustments to be shown to the nearest 1/10 of a pound.

4. User Programmability.

All temperature control strategies and energy management routings shall be definable by the operator through the operators' terminal. It shall be possible for the operator to modify system functions independently after receiving the training from the control contractor. The system shall be provided complete with all equipment and documentation necessary to allow a trained operator to independently perform the functions listed below:

-Read the value of a measured variable (i.e. temperature).
-Start or stop equipment.
-Monitor the status of equipment being controlled.
-Read the setpoint of a control loop.
-Determine the control strategies that have been defined for a specific piece of equipment.
-Generate displays of control strategies.
-Add/delete control loops to the system.
-Add/delete points to the system.
-Create, modify or delete control strategies.
-Assign sensors and/or actuators to a control strategy.
-Tune control loops through the adjustment of control loop parameters.
-Enable or disable control strategies.
-Generate hardcopy records of control strategies on a printer.
-Select points to be alarmable and define the alarm state(s).

J. Programming

1. Include all programming necessary to perform the sequences of operation as specified.

2. Submit the logic programming to Engineer for review and comment. Include time to personally the program logic with the Engineer.

3. Submit to the Owner (Engineer) a complete list of the alarms to be annunciated by the system including typical families of analog limit alarms with their proposed values. The owner will provide a custom text relative to each alarm point including instructions as to what action to be taken.

4. The system shall be capable of supporting proportional, proportional-integral, and proportional-integral-derivative control alogarithms.

5. Custom graphics are to be prepared by the DDC system vendor for each mechanical system indicted on the contract flow and control diagram, or for which there is a unique sequence of operation indicated in PART 3 of this specification section.

K. Training/owner's instruction: The control system contractor shall provide four copies of an operator's manual describing all operating and routine maintenance service procedures to be used with the system. The control contractor shall instruct the owner's designated representatives in these procedures during the start up and period. The duration of the instruction period shall be no less than 40 hours. These instructions are to be conducted during normal working hours. The instructions shall consist of both hands-on and classroom training at the job site. The Owner reserves the right to video tape these instruction periods.

L. Valves

1. Control valves shall be selected with a maximum pressure drop of 5.0 psi for valves 2" and larger and 2.0 psi for valves smaller than 2".

2. Valves shall be single seated for tight shut off against system pressures encountered during the full range of operation.

3. "Motorized" butterfly valves shall be Dezurik HP with double acting high pressure rotary cylinder actuators for two position service. Type T actuators for valves 6" and smaller; type G gear actuator for sizes 8" and larger.

   For modulating service provide rotary diaphragm actuators, complete with pilot positioners, suitable for operation with 55 psi compressed air.
   See Section 230523 for details of valve construction.

PART 3 - EXECUTION

3.01 AUTOMATIC CONTROLS - GENERAL

A. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. Junction boxes and/or circuit breakers for the automatic control system are provided under another division of these specifications. All field wiring (including low voltage and 120 volt power), to all control panels and electric control components of the automatic control system shall be provided and installed by the Division 23 mechanical contractor, extended from sources indicated on the electrical drawings.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by, or under the supervision of the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

D. Conceal control conduit and piping and capillaries in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistats 4'-6" above the floor measured to the center line of the instrument. Room devices are to be of the concealed adjustment type without indicator.

G. Install outdoor thermostats in perforated tube and sunshield.

H. Static pressure sensors shall be located as far from the fan as possible.

I. Electronic and pneumatic space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

J. Install control wiring in EMT conduit. Flexible metal conduit, up to 36 inches in length, shall be permitted for final connections to devices. MC cable may be used for 120 volt control wiring where run within concealed spaces, such as walls and above hung or furred ceilings.

K. Low voltage, plenum-rated control wiring may be installed without conduit where run in accessible concealed ceiling spaces. Wiring shall be run in EMT in all cases where stubbed down into walls and run below 8 feet.

L. Exposed raceways run within 8’ of finished floor in garages, mechanical rooms, elevator machine rooms, loading docks and elsewhere where subject to mechanical damage shall be rigid galvanized steel conduit.

M. “Bridle ring” type supports may be used for support of control system cables where permitted above to be run without conduit. “Bridle rings” shall be supported by bolt-on C-clamps or trapeze hangers. Do not use “tie-wraps” for cable attachment to other support systems.

3.02 ADJUSTMENTS AND TESTS

A. Adjust and calibrate controls and test all safety devices when systems are operative for the required performance prior to the performance tests.

B. At final performance test, demonstrate performance of controls and safety devices.

C. Adjustment and tests are to be performed by the control manufacturer.

D. Excluding the work called for in Paragraphs A through C above, the control contractor shall, as part of his proposal, allow for an additional 80 hours of qualified mechanics' time for system readjustment and/or instruction of Owner's personnel.

3.03 PERFORMANCE

A. Unless stated otherwise, control temperatures within plus or minus $2^{o}F$ and humidity within plus or minus 5% of the set point.

B. Provide fully compensated capillaries with remote bulb instruments.

3.04 EVENT INITIATED TRENDING

A. In the event that the temperature or humidity of any zone shall enter alarm condition, the DDC system shall begin a trend of the parameters which affect the ability of the system to maintain conditions.

B. The points trended shall be similar but not limited to:

1. Air handling unit discharge temperature.
2. Air handling unit discharge humidity.
3. Zone supply air temperature.
4. Chilled water supply and return temperature.
5. Pre-treatment system supply temperature.
6. Pre-treatment system supply humidity.
7. Hot water supply and return temperature.
8. Outside air temperature and relative humidity.

C. The DDC system shall plot the variables on a single real time graphic display.

D. The DDC system shall monitor these points at 2 minute intervals and periodically download the values into Microsoft Excel.

3.05 SEQUENCE OF OPERATION – AIR COOLED CHILLER (CH-1)

A. On a call for cooling (when any chilled water control valve is open), the lead chilled water pump shall be commanded to start, once flow has been proven by the local chiller controller, the chiller will operate under its own control to maintain its discharge chilled water temperature set point as determined at the BMS workstation. The lead chilled water pump VFD shall be modulated to maintain chilled water flow through the system equal to the design chilled water flow (428gpm).

B. In the event that the lead chilled water pump does not provide proven chilled water flow within 10 minutes (adjustable), an alarm will register at the BMS workstation,

the lead chilled water pump will be commanded to stop and the lag chilled water pump will be commanded to start. Once flow has been proven by the local chiller controller, the chiller will operate under its own control to maintain its discharge chilled water temperature set point as determined at the BMS workstation. The lead chilled water pump VFD shall be modulated to maintain chilled water flow through the system equal to the design chilled water flow (428gpm).

C. In the event that there is no call for cooling (no chilled water control valve is open) for 45 minutes (adjustable), the chiller shall become inactive and the lead chilled water pump will turn off.

D. The initial critical chilled water set point shall be 42°F. The initial normal chilled water set point shall be 45°F. In critical mode, the chilled water set point shall be maintained with tight tolerance, while in normal mode the chilled water set point shall be maintained with a greater tolerance. Both tolerances shall be adjustable from the BMS workstation.

3.06 SEQUENCE OF OPERATION –AIR HANDLING SYSTEMS (AHU-1/RF-1, AHU-2/RF-2, AHU-3/RF-3, AHU-4/RF-4 & AHU-5)

A. General

1. The unit shall be enabled and disabled through the BMS system. All control functions shall be accomplished through the BMS system.

2. The Operator shall have the ability to choose critical mode, normal mode heating or normal mode cooling as well as schedule the occupied and unoccupied schedules.

B. Disabled Mode

1. When the units are disabled; the supply and return fans shall be off, the humidifier steam generator shall be disabled, the chilled water control valve shall be closed and all reheat coil control valves shall be closed.

C. Critical Operating Mode

1. When the unit is enabled in critical operating mode by the BMS, the return air damper shall be fully opened, the outside air and relief air VAV boxes shall be closed, the supply fan and return fan shall be commanded to start and operate continuously. The supply fan and return fan VFDs shall individually modulate to maintain the critical airflow set point (adjustable, initially set to sum of zone design air flows) at each of the two fans using inlet flow monitoring stations.

2. In critical mode, the zone air flow set points shall be adjustable and initially set to the design air flow values. In critical set back mode, the zone air flow set points shall be adjustable and initially set to 80% of the design air flow values.

3. When the system is in the occupied mode, the BMS shall modulate the return air damper, pretreatment ventilation VAV box and pretreatment relief air VAV box to satisfy the system return air carbon dioxide set point (adjustable). When the system is in unoccupied mode, the pretreatment ventilation and relief air VAV boxes shall be closed.

4. The critical set point dew point shall be calculated by the BMS system based on the critical space temperature set point (adjustable, initially 70°F) and the critical space relative humidity set point (adjustable, initially 50%RH). The zone dew points shall be calculated by the BMS system based on the zone space temperature and zone space relative humidity measurements. The average measured dew point shall be calculated by the BMS system based on the calculated dew points for all zones served by each air handling unit.

5. When the average measured zone dew point is below the set point dew point, the BMS shall command the system humidifier on. The humidifier steam generator shall be modulated by the BMS system to maintain the average measured dew point when compared with the calculated set point dew point.

    a. A discharge high limit sensor shall overcall the humidifier steam generator modulation to limit the relative humidity in the supply duct to 80% (adjustable).

6. When the space relative humidity set point is adjusted by the operator, a "humidity ramp sequence" shall limit the set point change as a function of time. The maximum humidity set point adjustment over a 24-hour period shall be 4% RH. This sequence may be overridden by operator command.

7. The system cooling coil control valves shall be modulated to satisfy, whichever of the following criteria requires the cooling coil control valve to be opened more:

    a. The cooling coil control valve shall modulate to maintain average space temperature set point.

    b. The cooling coil control valve shall modulate open when the average measured space dew point is above the calculated set point dew point.

c. Units with multiple cooling coils shall have one control valve per coil. The BMS shall modulate the control valve for the lowest coil first. Once the lowest cooling coil control valve is fully open, the BMS shall modulate the next cooling coil control valve.

d. When the average measured zone dew point is below the set point dew point, all cooling coil control valves shall modulate together.

8. The system heating coil control valves shall be modulated to maintain the zone temperature set point in the zone requiring the least heat.

9. The reheat coil control valves shall modulate to maintain zone space temperature set point.

10. Each zone shall have a critical airflow set point (adjustable) and a critical setback airflow set point (adjustable). When the system is in occupied mode, the system shall operate to maintain the critical set points. When the system is in unoccupied mode, the system shall operate to maintain the critical setback set points. Initially the critical and critical setback set points shall be equal to the design airflows.

D. Normal Operating Mode

1. When the unit is enabled in normal operating mode by the BMS, the return air damper shall be fully opened, the outside air and relief air VAV boxes shall be closed, the supply fan and return fan shall be commanded to start and operate continuously.

2. In normal operating mode, the zone CV boxes will act as VAV boxes. The air flow will be modulated by the BMS to maintain the normal cooling set point (adjustable, initially 73°F).

3. In heating mode, the BMS will modulate the zone CV/VAV boxes to maintain the minimum ventilation air flow per the Ventilation Air Table on the mechanical schedules.

4. The system heating coil control valves shall be modulated to maintain the zone temperature set point in the zone requiring the least heat.

5. The zone reheat coil control valves shall modulate to maintain zone space temperature set points (adjustable, initially 68°F).

6. In unoccupied mode, the system will operate to maintain the zone set back cooling temperature set point (adjustable) and zone set back heating temperature set point (adjustable).

7. The system supply fan shall be modulated to maintain the duct static pressure set point.

   a. When any VAV damper is more than 75% (adj.) open, the supply fan discharge duct static pressure set point shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75% open or the static pressure set point has reset upward to the system maximum duct static pressure set point or the AHU variable-frequency drive is at the maximum speed setting.

   b. When all VAV dampers are less than 65% (adj.) open, the supply fan discharge duct static pressure set point shall be reset downward by 0.1 in W.C.(adj.), at a frequency of 15 minutes (adj.), until at least one damper is more than 65% open or the static pressure set point has reset downward to the system minimum duct static pressure set point or the AHU variable-frequency drive is at the minimum speed setting.

   c. The control bands, set point increment values, set point decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.

   d. The operator shall have the capability to exclude “problem” zones that should not be considered when determining the optimized set point.

   e. The BMS shall also read the status of the supply air static pressure sensor and display the active duct static pressure reading on the status screen.

   f. The BAS shall have the ability to identify, and display to the user, the VAV box that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure set point optimization control.

   g. During the commissioning process, the controls contractor shall demonstrate the performance of fan pressure optimization

8. When the system is in the occupied mode, the BMS shall modulate the return air damper, pretreatment ventilation VAV box and pretreatment relief air VAV box to satisfy the system return air carbon dioxide set point (adjustable). When the system is in unoccupied mode, the pretreatment ventilation and relief air VAV boxes shall be closed.

9. The normal set point dew point shall be calculated by the BMS system based on the normal space temperature set point (adjustable, initially 70°F)

and the normal space relative humidity set point (adjustable, initially 50%RH). The zone dew points shall be calculated by the BMS system based on the zone space temperature and zone space relative humidity measurements. The average measured dew point shall be calculated by the BMS system based on the calculated dew points for all zones served by each air handling unit.

10. When the average measured zone dew point is below the set point dew point, the BMS shall command the system humidifier on. The humidifier steam generator shall be modulated by the BMS system to maintain the average measured dew point when compared with the calculated set point dew point.

    a. A discharge high limit sensor shall overcall the humidifier steam generator modulation to limit the relative humidity in the supply duct to 80% (adjustable).

11. When the system is in cooling mode, the cooling coil control valve shall modulate to maintain the cooling space temperature set point in the zone requiring the most cooling. Units with multiple cooling coils shall have one control valve per coil. The BMS shall modulate the control valve for the lowest coil first. Once the lowest cooling coil control valve is fully open, the BMS shall modulate the next cooling coil control valve.

12. The BMS shall determine the interior enthalpy based on the system return air temperature and return air relative humidity. The BMS shall determine the outside enthalpy based on the outside air temperature and outside air relative humidity. When the air handling systems are in normal cooling mode and the outdoor enthalpy is below the return air enthalpy, the BMS shall close the pretreatment ventilation air and relief air VAV boxes, modulate the return air, outside air and relief air dampers as the first stage of cooling. When the outside air and relief air dampers are full open and the zones are still calling for cooling, the BMS shall modulate the cooling coil control valves to maintain the zone temperature set point that requires the most cooling.

13. When the system is in Unoccupied Mode, the heating, cooling and humidification sequences described above shall use the set back supply fan air flow set point (adjustable, initially 2,000 cfm), setback cooling temperature set point (adjustable, initially 80°F), setback heating temperature set point (adjustable, initially 65°F), and setback heating relative humidity set point (adjustable, initially 10%RH). The supply fan shall be cycled off at times when the relevant set points are maintained.

E. Safeties and Alarms

1. A freeze-stat located upstream of the hot water coil shall send a signal to

the Operator's Workstation when the air temperature sensed on any segment of the serpentine sensing element has dropped below 20°F (adjustable). Upon activation of the freeze-stat the supply fan shall be disabled and alarms shall be initiated at the Operator's Workstation and at the local control panel. The freeze-stat shall be reset locally with its own manual reset button.

2. Upon activation of any duct smoke detector, the supply fan shall shut down. The fire alarm system shall be wired directly to the fan start circuit.

3. Upon activation of any smoke detector, an alarm shall be initiated at the Operator's Workstation and at the local control panel. Smoke detectors shall be furnished, installed and wired to the fire alarm system by Division 16. Smoke detectors shall be located per Division 15 shop drawings.

4. A water sensor located in the drain pan below each AHU shall send a signal to the Operator's Workstation when water is sensed in the drain pan. Upon activation of the water sensor, the local supply fan shall be disabled and alarms shall be initiated at the Operator's Workstation and at the local control panel.

3.07 SEQUENCE OF OPERATION – AIR HANDLING UNIT (AHU-6)

A. General

1. The unit shall be enabled and disabled through the BMS system. All control functions shall be accomplished through the BMS system.

2. The Operator shall have the ability to choose normal mode heating or normal mode cooling as well as schedule the occupied and unoccupied schedules.

B. Disabled Mode

1. When the units are disabled; the supply and return fans shall be off, the chilled water control valve shall be closed and all reheat coil control valves shall be closed.

C. Normal Operating Mode

1. When the unit is enabled by the BMS, the return air damper shall be fully opened, the supply fan shall be commanded to start and operate continuously.

2. In cooling mode, the cooling coil control valve shall be modulated to maintain the system space temperature set point (adjustable, initially 73°F).

3. In cooling mode, the cooling coil control valve shall be modulated to maintain

the system space temperature set point (adjustable, initially 68°F).

4. In unoccupied mode, the system will operate to maintain the system set back air flow set point (adjustable), the zone set back cooling temperature set point (adjustable) and zone set back heating temperature set point (adjustable).

5. When the system is in the occupied mode, the BMS shall modulate the return air damper, outside air damper and relief air damper box to satisfy the system return air carbon dioxide set point (adjustable). When the system is in unoccupied mode, the dampers shall be closed.

6. The BMS shall determine the interior enthalpy based on the system return air temperature and return air relative humidity. The BMS shall determine the outside enthalpy based on the outside air temperature and outside air relative humidity. When the air handling systems are in normal cooling mode and the outdoor enthalpy is below the return air enthalpy, the BMS shall modulate the return air, outside air and relief air dampers as the first stage of cooling. When the outside air and relief air dampers are full open and the zones are still calling for cooling, the BMS shall modulate the cooling coil control valve to maintain the system space temperature set point.

D. Safeties and Alarms

1. A freeze-stat located upstream of the hot water coil shall send a signal to the Operator's Workstation when the air temperature sensed on any segment of the serpentine sensing element has dropped below 20^{o}F (adjustable). Upon activation of the freeze-stat the supply fan shall be disabled and alarms shall be initiated at the Operator's Workstation and at the local control panel. The freeze-stat shall be reset locally with its own manual reset button.

2. Upon activation of any duct smoke detector, the supply fan shall shut down. The fire alarm system shall be wired directly to the fan start circuit.

3. Upon activation of any smoke detector, an alarm shall be initiated at the Operator's Workstation and at the local control panel. Smoke detectors shall be furnished, installed and wired to the fire alarm system by Division 16. Smoke detectors shall be located per Division 15 shop drawings.

4. A water sensor located in the drain pan below each AHU shall send a signal to the Operator's Workstation when water is sensed in the drain pan. Upon activation of the water sensor, the local supply fan shall be disabled and alarms shall be initiated at the Operator's Workstation and at the local control panel.

3.08 SEQUENCE OF OPERATION – OUTSIDE AIR UNIT

A. The BMS will send the controller Occupied, Unoccupied, Optimal Start, Night Heat / Cool and Timed Override commands. The BMS will also send a discharge air temperature set point and a duct static pressure set point. If communication is lost with the BMS, the controller will operate in the occupied cooling mode using its default set points.

B. Occupied: During Occupied periods the supply and exhaust fans will run continuously and the outside air damper will open to maintain minimum ventilation requirements.

1. Cooling Mode: The energy recovery wheel, or economizer and chilled water control valves will modulate in sequence to maintain the discharge air temperature cooling set point (adjustable, initially set to 55°F). If the discharge air temperature sensor fails during normal operation all associated valves will close and an alarm will be annunciated. When conditions are favorable (outside air enthalpy above return air enthalpy), the energy recovery wheel will be the first stage of cooling. The bypass dampers shall open to the heat recovery wheel position and the energy recovery wheel shall be commanded on. If the energy recovery wheel status does not match the commanded value after a delay (30 sec. adj.) the wheel shall be commanded off, the bypass dampers shall be commanded open to the bypass position, and an alarm shall be generated at the OWS. When conditions are favorable (outside air enthalpy below return air enthalpy), the economizer shall be the first stage of cooling. The bypass dampers shall open to the bypass position and the energy recovery wheel shall be commanded off and the economizing sequence shall be active. The chilled water control valves will modulate as second stage cooling to maintain the discharge air temperature cooling set point (adjustable, initially set to 55°F). If the discharge air temperature sensor fails during normal operation associated valve will remain open and an alarm will be annunciated.

2. Heating Mode: The energy recovery wheel and hot water control valves will sequence. When conditions permit, the Energy Recovery Wheel shall be the first stage of heating. The bypass dampers shall open to the heat recovery wheel position and the energy recovery wheel shall be commanded on. If the energy recovery wheel status does not match the commanded value after a delay (adjustable, initially set to 30 seconds) the wheel shall be commanded off, the bypass dampers shall be commanded open to the bypass position, and an alarm shall be generated at the OWS. The hot water control valves will modulate to maintain the discharge air temperature heating set point (adjustable, initially set to 85°F). If the discharge air temperature sensor fails during normal operation associated

valve will remain open and an alarm will be annunciated.

3. Energy Recovery Wheel Frost Control: A differential pressure sensor on the exhaust stream of the energy recovery wheel shall sense a frost condition. When the differential pressure rises above set point (adjustable, initially set to 0.5" w.g.) the outdoor air and exhaust air Energy Recovery Wheel Bypass Dampers shall open to the bypass position prevent airflow across the wheel and the wheel shall be commanded off.

C. Warm-up/Cool-down Mode: During Optimal Start periods, the supply and exhaust fans will run continuously and the outside air damper will remain closed unless the economizer sequence is active.

1. Warm-up Mode: when the space temperature is 1.5°F (adjustable) or more below the Occupied heating set point, a daytime warm-up sequence will be activated. The outside air damper will remain closed, and the hot water valve will modulate to maintain the discharge air temperature heating set point (adjustable, initially set to 185°F). The warm-up mode will terminate when the average space temperature reaches the Occupied heating set point or when the Occupied Sequence begins.

2. Cool-down Mode: when the space temperature is 1.5°F (adjustable) or more above the Occupied cooling set point, a daytime cool-down sequence will be activated. The economizer and chilled water control valve will modulate in sequence to maintain the discharge air temperature cooling set point (adjustable, initially set to 55°F). The cool down mode will terminate when the average space temperature reaches the Occupied cooling set point or when the Occupied Sequence begins.

D. Unoccupied (Night Setback): During Unoccupied Mode: The supply and exhaust fans will remain off unless there is a call for heating or cooling and the outside air damper will remain closed unless the economizer sequence is active.

1. Heating Mode: When the space temperature is below the Unoccupied heating set point (adjustable, initially set to 60°F) the supply fan will start, the outside air damper will remain closed and the hot water valve will open to maintain the discharge air temperature heating set point (adjustable, initially set to 85°F). When the space temperature rises above the Unoccupied heating set point (adjustable, initially set to 60°F) plus the Unoccupied differential (adjustable, initially set to 4°F) the supply fan will stop and the hot water valve will close.

2. Cooling Mode: When the space temperature is above the Unoccupied cooling set point (adjustable, initially set to 85°F) the supply fan will start, the outside air damper will remain closed unless the economizer sequence is active and the chilled water valve will open. The economizer and chilled

water control valve will modulate in sequence to maintain the DAT cooling set point (adjustable, initially set to 55°F). When the space temperature falls below the unoccupied cooling set point (adjustable, initially set to 85°F) minus the unoccupied differential (adjustable, initially set to 4°F) the supply fan will stop and the chilled water valve will close.

E. VAV Supply Fan: The fan will be off in the Unoccupied mode. When the controller is in the Occupied mode, the supply fan will operate continuously and its speed will be modulated to maintain the duct static pressure set point. If the supply fan fails to prove status for 30 seconds (adjustable), the fan will be commanded off, the outside air damper and all valves will close and an alarm will be annunciated. A manual reset is required to restart the fan. A hardwired, high static pressure cut-off switch is electrically interlocked with the variable speed drive. If the high static pressure cut-off switch is tripped the fan will stop, the outside air damper and all valves will close and an alarm will be annunciated. A manual reset of the high static pressure cut-off switch will be required to restart the fan.

F. The duct static pressure set point is sent by the BMS and is reset by the discharge duct static pressure set point optimization sequence.

1. When any VAV damper is more than 75% (adj.) open, the supply fan discharge duct static pressure set point shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75% open or the static pressure set point has reset upward to the system maximum duct static pressure set point or the AHU variable-frequency drive is at the maximum speed setting.

2. When all VAV dampers are less than 65% (adj.) open, the supply fan discharge duct static pressure set point shall be reset downward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until at least one damper is more than 65% open or the static pressure set point has reset downward to the system minimum duct static pressure set point or the AHU variable-frequency drive is at the minimum speed setting.

3. The control bands, set point increment values, set point decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.

4. The BMS shall have the capability to allow the operator to exclude “problem” zones that should not be considered when determining the optimized set point.

5. The BMS shall also read the status of the supply air static pressure sensor and display the active duct static pressure reading on the status screen.

6. The BMS shall have the ability to identify, and display to the user, the VAV box that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure set point optimization control.

7. During the commissioning process, the controls contractor shall demonstrate the performance of fan pressure optimization

G. Exhaust Fan: The exhaust fan will be off in the Unoccupied mode. When the controller is in the Occupied mode, the exhaust fan will operate continuously and its speed will be modulated to track the supply fan speed minus an offset (5% adj.) If the exhaust fan fails to prove status for 30 seconds (adj), both fans will be commanded off, the outside air damper and all valves will close and an alarm will be annunciated. A manual reset is required to restart the fan.

H. Ventilation Optimization: The AHU outdoor-air damper shall be controlled to deliver required outdoor airflow at all load conditions. The outdoor airflow set point shall be determined according to ASHRAE Standard 62.1-2004, Equation 6-8 and Appendix A. The actual outdoor airflow shall be sensed at the outdoor air intake.

1. The BMS shall include a time-of-day schedule to indicate whether a zone is normally occupied or unoccupied. When the schedule indicates that the zone is normally unoccupied, the required outdoor airflow for the zone shall be zero. When the schedule indicates that the zone is normally occupied, the required outdoor airflow for the zone shall be continuously calculated using the measured zone CO2 concentration as an indicator of the current per-person ventilation rate.

2. The required outdoor-air fraction shall be continuously calculated for each VAV terminal zone. Outdoor-air fraction is defined as the current required outdoor airflow for the zone divided by the current primary airflow to the zone.

3. The BMS shall regularly determine the highest zone outdoor-air fraction, sum the outdoor airflow requirements for all VAV zones, and sum the current primary airflows for all VAV zones to determine the total system primary airflow. This information shall be used in Equation 6-8 and Appendix A of ASHRAE Standard 62.1-2004 to calculate the minimum required outdoor airflow for the system. This minimum outdoor airflow set point shall be recalculated every 15 minutes (adjustable).

4. The VAV Air System shall not request a higher percentage of outdoor air than the AHU is able to provide. This Ventilation Ratio Limit (adjustable) of the AHU is dependent on the capacity of the AHU and the current outdoor air temperature and humidity conditions.

5. Prior to final system acceptance, a contractor shall provide a trend log of actual system operation to the engineer and owner. Operating conditions to be logged include: highest zone outdoor-air fraction, total system primary airflow, calculated outdoor airflow set point for the system, and the actual measured outdoor airflow. These conditions must be logged at 15-minute intervals over a typical 48-hour period.

I. Economizer Damper Control: When the outdoor wet bulb (enthalpy) is below return air enthalpy, the outdoor air damper and mechanical cooling will be controlled to maintain the supply air temperature at set point. Mechanical cooling will be locked out and the outdoor air damper will modulate between the minimum position and 100% open to allow outdoor air to be delivered for free cooling. If the outdoor air damper reaches 100% open and the supply air temperature set point cannot be maintained using outdoor air alone, the outdoor air damper will be held 100% open and mechanical cooling will be enabled. When the outdoor air wet bulb (enthalpy) is above return air enthalpy, the outdoor air damper will be controlled to minimum position and mechanical cooling will be controlled to maintain the supply air temperature at set point.

J. Freeze Protection: The initial damper opening rate will be limited to 2% per minute until the damper has reached its minimum ventilation position. The outside air damper will modulate to a position less than the minimum damper position if the mixed air temperature drops below 50°F (adjustable). If the mixed air temperature sensor fails the outside air damper will close and an alarm will be annunciated. A hardwired, low limit temperature switch is electrically interlocked with the variable speed drive. If the low limit temperature switch is tripped (38°F adjustable), the outside air damper will close, all valves will open to 100% and an alarm will be annunciated. A manual reset of the low limit temperature switch will be required to restart the fan.

K. Filter Status: Differential pressure switches will monitor the differential pressure across the filters when the fans are running. If the switch closes during normal operation a dirty filter alarm will be annunciated. Filters will be located as shown on drawings.

L. Return Air and Exhaust Air Damper Control: The Return and Exhaust Air Dampers shall be software interlocked with the Outside Air Damper. The Exhaust Air Damper shall be modulated to track the Outdoor Air Damper position. The Return Air Damper shall be modulated to inversely track the Outdoor Air Damper position.

3.09 SEQUENCE OF OPERATION – HOT WATER SYSTEM

A. On a call for heating the lead boiler shall be commanded to start and the lead hot water pump shall be commanded to start by the BMS. When there is no call for cooling, the lead boiler isolation valve shall remain open and the lag boiler isolation

valve shall be closed. After the boiler controllers have confirmed water flow, the boiler controller shall operate the boiler components to maintain the discharge hot water temperature set point as determined by the BMS system.

B. A manual emergency break glass switch located at the entrance to the boiler room shall shutdown all the boilers and all other mechanical equipment located in the boiler room.

C. The lead hot water pump shall be started automatically by the BMS system and run continuously. The lag hot water pump shall be automatically started upon failure of the lead hot water pump. Lead/lag hot water pumps shall be automatically alternated weekly, to equalize operation of the hot water pumps. In addition, the operator shall be able to manually select the lead hot water pump, overriding the automatic selection.

D. The balancing agent shall determine the initial hot water system differential pressure set point during the water balancing process with the hot water pump VFD operating at the lowest speed possible to facilitate the water balance.

E. The BMS shall modulate the lead hot water pump VFD to maintain the system differential pressure set point.

1. When the lead hot water pump VFD speed drops to a minimum speed (as recommended by the pump manufacturer) the hot water bypass valve shall be modulated open to maintain minimum hot water flow through the active boiler(s) as recommended by the boiler manufacturer.

2. When the lag boiler is inactive and the hot water system water flow is measured above 260 gpm (adjustable), the lag boiler isolation valve shall be opened, the lag hot water pump shall be commanded on and the lag boiler shall be commanded on.

3. While both hot water pumps are active, they shall be modulated together to maintain the system differential pressure set point described above.

4. When both boilers and hot water pumps are active and the hot water system water flow is measured below 200 gpm (adjustable), the lag hot water pump and lag boiler shall both be commanded off. The lag boiler isolation valve shall be closed after a delay (initially 1 minute).

F. The hot water system differential pressure sensor shall be located 2/3 hydraulically down the hot water distribution system. This contractor is to submit the differential pressure sensor location to the Engineer for review before proceeding to the Coordination Drawing process.

G. The BMS shall adjust the hot water supply set point shall be reset inversely to the

outdoor temperature, in accordance with the following schedule:

Outdoor Temperature	Hot Water Supply
0°F	160 °F (adjustable)
30°F	140 °F (adjustable)
60°F	120 °F (adjustable)

3.10 SEQUENCE OF OPERATION – OUTSIDE AIR UNIT

A. The BMS shall enable and disable the Outside Air Unit, monitor alarms and control the ventilation airflow set points of each Outside Air Unit.

B. The BMS shall monitor the ventilation airflow set point shall be scheduled based on the occupied/unoccupied status and monitored carbon dioxide concentration levels of each AHU system.

C. When the Outside Air Unit is enabled and the outdoor air temperature is below 60°F (adjustable), the BMS shall modulate the reheat coil control valve to maintain discharge set point temperature (adjustable, initially set to 65°F).

D. When the Outside Air Unit is enabled, the BMS shall modulate the local humidifier steam generator output to maintain discharge set point relative humidity (adjustable, initially set to 40%RH). The BMS shall enable/disable each humidifier steam generator, monitor alarms and send individual modulating output signals. Each humidifier system shall include internal safeties including, but not limited to, airflow proving switch and duct high limit humidity sensor.

3.11 SEQUENCE OF OPERATION – TOILET EXHAUST FANS

A. When any of the toilet room light switches are turned ON, the BMS shall open the associated exhaust air motorized damper and command the associated toilet exhaust fan to start. 15 minutes (adjustable) after all of the toilet room light switches are turned OFF, the BMS shall command the toilet exhaust fan off and close the associated exhaust air motorized damper.

3.12 SEQUENCE OF OPERATION – EXHAUST FANS

A. When the space temperature is measured above the space temperature set point, the BMS shall open the associated outside air and exhaust air motorized dampers and command the exhaust fan to start. Once the space temperature set point is met, the BMS shall command the exhaust fan off and close the associated outside air and exhaust air motorized dampers.

3.13 SEQUENCE OF OPERATION – DOMESTIC HOT WATER RECIRCULATION PUMPS

A. When the building is in occupied mode, the BMS shall enable or disable the domestic water recirculation pumps to maintain the recirculation water temperature set point (adjustable).

3.14 SEQUENCE OF OPERATION – MONITORING POINTS

A. The BMS shall monitor general conditions, which are typically not used in any of the other above sequences and report alarms for each point based on BMS Operator values.

B. The points include, but are not limited to: typical plumbing water sensor panels, electrical surge protection devices, electrical meters, outdoor air temperature, outdoor air relative humidity, typical space carbon dioxide levels and typical toilet room light switches.

END OF SECTION 23 09 23

SECTION 23 20 00

PUMPING EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, general provision, and with the provisions of all applicable codes and laws.

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Centrifugal pumps.
2. Air conditioning condensate pump.
3. Pump related accessories.
4. Pump curves.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

PART 2 - PRODUCTS

2.01 GENERAL

A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.

B. Provide casing connections for vent, drain, suction and discharge pressure gauges.

C. Balance impellers and all other moving components statically and dynamically.

D. Completely align and level pumps, motors and bases. Where pumps and motors are shipped as a unit, realign them in the field.

E. Install and align mechanical seals in accordance with the manufacturer's recommendations.

F. Provide water supply for cooling and lubricating of seals and/or packing.

G. Match centrifugal pump impellers and casings so that at specified operating conditions, the impeller diameter is not more than 90% of the maximum diameter impeller which can satisfactorily operate in the casing.

H. Pumps must operate stably without pulsation, vibration or internal recirculation. Pump operating characteristics at the design point must be such that a variation of 10% in head results in not more than 15% variation in GPM and does not affect the stability of operation of the pump.

I. Motor sizes scheduled are minimum for the specific pumps indicated on pump schedules. When submitting pumps other than those specifically selected, size motors so that when operating at rated RPM, the pump motor brake horsepower does not exceed the nominal motor rating despite variations in pumping head or when operated singly or in parallel with other pumps serving the same system.

J. Motors to be high efficiency type with guaranteed minimum efficiency rated in accordance with IEEE standard 112, method B - General Electric Company "Energy Saver" or equal.

2.02 PUMP - CENTRIFUGAL - END-SUCTION - SINGLE STAGE, STANDARD CONSTRUCTION

A. Single suction base mounted single stage centrifugal type with pump flexibly coupled to the motor and the assembly mounted as a unit on a cast iron or formed steel base plate. Provide a steel coupling guard bolted to the pump base plate.

B. Casing - Cast iron volute, vertically split, bolted at the division, replaceable bronze wearing rings locked on.

C. Pressure ratings - minimum 125 PSI WWP, 125 PSI ANSI-Standard flanged or screwed connections.

D. Impellers - Fully enclosed, bronze, keyed to the shaft.

E. Shaft - Alloy steel, ground smooth.

F. Shaft sleeves - aluminum bronze locked on the shaft extending from the impeller through the shaft seal.

G. Mechanical seals - Ni-resist and carbon sealing faces, Crane Packing Co. type 1. Provide water lubrication by copper tubing connections with casing.

H. Bearings - Heavy duty grease lubricated ball type. Protected from water by slinger rings on shaft.

I.

Manufacturer:	Model/Series:
Bell & Gossett	1510
Peerless	F
Weinman	500

2.03 PUMP - CENTRIFUGAL INLINE

A. Single suction, close coupled centrifugal type with pump bolted to the motor housing, and the complete assembly mounted as a unit.

B. Fully enclosed bronze impeller keyed to a stainless steel shaft.

C. Shaft seal: Mechanical, designed for hot water service to 230^{O}F.

D.

Manufacturer:	Model/Series:
Bell and Gossett	60,80,90
Peerless	
Weinman	

2.04 AIR CONDITIONING CONDENSATE PUMP (LARGE)

A. Complete assembly of receiver, pump, and motor float switch.

B. Receiver shall be fabricated steel with 10 gallon capacity.

C. Pump shall be constructed with stainless steel shaft bronze bearing and aluminum non clog impeller. Pump shall be capable of 10 GPM at 20 ft. head.

D. Motor shall be 1/3HP, 1750 RPM, 120 volts, single phase, 60 Hz, with built-in overload protection.

E. Float operated switch shall be factory wired to motor.

F. Manufacturer: Federal — Model/Series: ALTV

2.05 AIR CONDITIONING CONDENSATE PUMP (SMALL)

A. Complete assembly of receiver, pump, and motor float switch.

B. Receiver shall be ABS plastic with 1 gallon capacity.

C. Vertical type pump shall be constructed with stainless steel shaft bronze bearing and Polypropylene impeller. Pump shall be capable of 125 GPH at 9 ft. head.

D. Motor shall be 1/50HP, 1750 RPM, 120 volts, single phase, 60 Hz, with built-in overload protection.

E. Pump features a safety switch that can be connected to shut down the air conditioner condenser or wired to an alarm to warn of possible tank overflow.

F. Discharge shall be a 3/8" O.D. barbed tubing adapter. Pump shall be rated for high-efficiency gas furnace applications that produce an acidic condensate.

G. Thermally protected motor shall be UL and CSA listed.

H. Manufacturer: Little Giant — Model/Series: VCL-14

PART 3 - EXECUTION

3.01 EQUIPMENT

A. Install equipment in conformance with manufacturer's recommendations.

END OF SECTION 23 20 00

SECTION 23 25 00

SPECIALTIES AND ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. The installation and equipment is to conform to applicable building Code articles and applicable reference standards cited therein.

C. Conform to the applicable performance standards, listing or approvals of the following organizations where cited in the Sections or on Drawings.

Underwriters Laboratories (UL)
National Fire Protection Association (NFPA)
American Society for Testing Materials (ASTM)

1.03 SUBMITTALS

A. Procedure

B. Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

C. Shop Drawings

1. Water treatment equipment components, trim, controls and performance data.

2. A complete list of all chemicals to be used.

3. Readings required on all indicating instruments for proper operation.

4. Equipment maintenance requirements.

5. Provide complete wiring diagrams for use by the electrician in connecting motors and equipment.

6. Complete piping diagrams for use by the Mechanical Contractor in installing interconnecting piping, tanks, pumps and metering devices.

7. Certification, on the company's letterhead, of qualifications of key personnel.

8. Electric tracer cable

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000.

PART 2 - PRODUCTS

2.01 WATER TREATMENT

A. General requirements.

1. The water treatment contractor shall provide a supervised water treatment program for a period of one year from the date of initial treatment, for the systems and/or equipment indicated hereafter.

2. The water treatment company shall have at least one officer or official holding a college or university degree in chemistry, chemical engineering, or sanitary engineering. He should have at least ten years experience in treating the water in systems of similar size and capacity, and he shall be in active responsible charge of all treatment work.

3. The company's laboratory shall be equipped to analyze samples in accordance with the standard methods of the American Water Works Association and the American Society for Testing Materials.

4. The water treatment contractor shall supply all feeding equipment including tanks, pumps, interconnecting piping and wiring, metering devices and accessories necessary to make a complete operable system. The Mechanical Contractor shall be responsible for installation of the above equipment and shall provide all piping, valves, fittings, switches and

miscellaneous equipment shown on the water treatment company's drawings but not supplied by the water treatment company.

5. The water treatment company shall provide the following services:

   a. Provide the Owner with complete written instructions for chemical feeding bleed-off and testing procedures.

   b. Demonstrate to Owner's personnel the proper application of written instructions.

   c. Provide all chemicals, chemical feeding equipment and testing equipment, as described in the following paragraphs. The products shall be biodegradable compounds.

   d. Obtain samples from all systems, at least once per month, analyze these samples and furnish written reports and recommendations to Owner and/or Engineer.

   e. Instruct Mechanical Contractor on installation of feeding equipment.

B. Initial Cleanout.

1. All new recirculating water systems, both open and closed, shall be filled and flushed with a 0.25 solution, by weight, of a non-foaming chemical detergent, to remove all foreign matter.

2. Solution shall be circulated for a minimum of 8 hours and drained as rapidly as possible to remove all suspended matter.

3. The system should be flushed with fresh water, drained a second time and refilled. After final filling, the PH of the water shall not exceed the PH of the fresh incoming water by more than 0.5 PH.

C. Chemicals

1. Chilled water

Treatment and Chemical Conditions	Control Level
Non-chromate corrosion inhibitor Vaporene N liquid or equal	500 PPM nitrite (Hot water 1000 - 1200 PPM nitrate

Testing equipment specifications: Provide all necessary field test equipment for maintaining control of treatment standards and cycles of concentration as above. Test kits shall be supplied by the water treatment contractor and remain the property of the Owner.

D. Closed Systems

1. Chilled water system: Mechanical Contractor shall install across the recirculating pump a 5-gallon by-pass feeder 250 PSI test pressure with 2" fill line and cap, as outlined on the Drawings. (See Metropolitan Refining Co., Inc. Drawing #11162).

2. Hot Water System: Mechanical Contractor shall install across the recirculating pump a 5-gallon by-pass feeder 250 PSI test pressure with 2" fill line and cap, as outlined on the Drawings. (See Metropolitan Refining Co., Inc. Drawing #11162).

E. Service Contract.

1. Furnish test unit with apparatus for treatment control of all chemical formulas supplied.

2. A service contract shall also be furnished for a one-year period which shall include the following: Initial water analysis and recommendations, system start-up assistance, training of operating personnel, periodic field service and consultation.

2.02 ELECTRICAL TRACERS FOR FREEZE PROTECTION

A. To be provided on all new outdoor piping: (2) 16 AWG copper bus wires embedded in parallel in a self regulating polymer core that varies its power output to respond to temperature along its length. The system shall permit crossing of cable without overheating. The heater cable shall be covered by a radiation cross linked modified polyolefin dielectric jacket.

B. All components shall be U.L. listed. See Electrical Drawings for location.

C. Rating: Adequate to maintain minimum 40o~F in lines protected.

D. Cable manufacturer: Raychem XL-Trace or the approved equal of Chemelx.

E. Control: The heater cable shall have a self regulating turn down factor of 90%.

F. Thermostat manufacturer: Chromalox Type PIT-15 raintight thermostat.

G. Form a loop and wrap tracer cable around piping, fittings and valves according to manufacturer's recommendations with the following required length of cable allowed for each size gate/globe valve or strainer as listed.

1" valve = 3'-0" tracer cable
4" valve = 8'-0" tracer cable
8" valve = 15-0" tracer cable

Minimum watt density

<3":	5.0 watts/ft.
4":	5.0 watts/ft.
6":	8.0 watts/ft.
8":	(2) @ 5.0 watts/ft.
up to 14":	(2) @ 8.0 watts/ft.

H. For further installation details of cable and controls refer to manufacturer's recommendations.

PART 3 - EXECUTION

3.01 Install equipment in conformance with manufacturer's recommendations.

END OF SECTION 23 25 00

SECTION 23 30 00

DUCTWORK AND AIR OUTLETS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the Contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Typical duct construction details (elbows, taps, splits, transitions, plenums, supports).
2. Ductwork layouts at 3/8" scale, with match lines as necessary to maintain maximum sheet size of 48x36.
3. Fire dampers and sheet metal hardware.
4. Combination fire/smoke and smoke dampers and accessories.
5. Volume & motorized dampers, accessories and access doors.
6. Duct mounted smoke detector locations.
7. Grilles, registers, diffusers and terminal outlets.
8. Acoustical lining and application methods.
9. Air duct leakage test procedures.
10. Air duct leakage test report.
11. Air balance contractors qualifications, procedures and report format.
12. Air balance report.

C. Samples: Typical finished grilles and terminal air distributing devices. Color samples for pre-finished items. Samples will not be returned, nor used in the project.

D. Sheetmetal shop drawings shall be coordinated, showing the work of other trades, including but not limited to, sprinklers, light fixtures, conduits, structural steel, plumbing and HVAC piping. Refer to Specification Section 230000 Coordination drawings, for submission requirements. Drawings shall show the following, as a minimum:

1. Ductwork including sizes, bottom of duct elevations, material and pressure class.
2. Duct fittings, transitions, takeoffs, and flexible connections.
3. Equipment including, but not limited to, diffusers, grilles, fans, air handling units, air flow stations, humidifiers, coils, and sound attenuators.
4. Volume, fire, smoke, combination fire/smoke and automatic control dampers.
5. Duct smoke detectors.
6. Duct access doors.
7. Section views shall be provided for mechanical rooms and other sheet metal intensive spaces to clearly represent all sheet metal work.

E. Sheetmetal shop drawings shall be submitted on drawings no larger than 48” long by 36” high, at minimum 3/8”=1’-0” scale. Provide match lines and key plans as required.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000. Produce and maintain ventilation and air conditioning under operating criteria.

PART 2 - PRODUCTS

2.01 RECTANGULAR DUCTWORK

A. Construct all ducts and casings of lock forming quality sheet, light commercial galvanized coating class - ASTM - A525, 526, 527; stainless steel sheet ASTM - A480; aluminum sheet Alloy 3003-H-14. Metal thicknesses are U.S. Standard gauge. Duct joints, seams and reinforcing shall meet or exceed requirements as per SMACNA HVAC Duct Construction Standards 1995 edition.

B. Duct construction shall follow standards set forth in Tables 1-5 through 1-13M of SMACNA HVAC Duct Construction Standards 1995 edition. Ductwork shall be fabricated for the pressure and minimum gauge listed below. Minimum pressure construction shall be 3" WG.

C. Minimum gauges for rectangular ducts and fittings - 3" w.g. where either dimension is:

STEEL	DUCT DIMENSION
No. 24 ga.	Up to 12"
No. 22 ga.	13" to 30"
No. 20 ga.	31" to 54"
No. 18 ga.	55" to 72"
No. 16 ga.	73" and larger

2.02 ROUND AND FLAT OVAL DUCTWORK

A. Construct all ducts and fittings of lock forming quality sheet, light commercial galvanized coating class - ASTM - A525, 526, 527; stainless steel sheet ASTM - A480; aluminum sheet Alloy 3003-H-14. Metal thicknesses are U.S. Standard gauge.

B. Gauges for round and flat-oval ducts - low and medium pressure - unless noted otherwise on plans -

	SPIRAL LOCK SEAM	LONGI. SEAM
No. 26 gauge	Up to 8" dia.	---
No. 24 gauge	9" to 22"	Up to 8" dia.
No. 22 gauge	23" to 36"	9" to 22"
No. 20 gauge	37" to 50"	23" to 50"
No. 18 gauge	---	51" to 60"
No. 16 gauge	---	61" and larger

2.03 DUCT CLASSIFICATION

A. All ductwork shall be constructed to commercial SMACNA standards for internal pressures of 3 inches of static pressure (water gauge).

2.04 DUCT SEALING

A. All ductwork shall be sealed to SMACNA Seal Class A.

2.05 VOLUME DAMPERS

A. General - provide in ALL branch duct connections at mains to control and adjust the total volume of the system. Outlet dampers shall not be used for system adjustment.

B. Single Blade Dampers. Maximum width of single blade shall be 14", use opposed blade damper for height exceeding 14". Pre-manufactured dampers shall be part of an assembly complete with damper, frame, axle and bearings. The damper frame shall be installed internal to the duct and fastened with the appropriate hardware. The installation shall not interfere with the operation of the damper blade(s). Approved products for pre-manufactured devices are as follows:

Device	Manufacturer	Model
Rectangular	Air Balance	AC-111
	Greenheck	MBD-15
	Ruskin	MD25
Round	Air Balance	AC-112
	Greenheck	MBDR50
	Ruskin	MDRS25

C. Multiple Blade Dampers. Opposed blade damper shall be used where duct height exceeds 14". Approved products for pre-manufactured devices are as follows:

Opposed Blade	Air Balance	AC-2
	Greenheck	MBD-15
	Ruskin	MD35OB

D. On uninsulated round ducts, equip dampers with heavy duty locking quadrant. The locking quadrant shall be mounted on a 2" x 3" x 1/8" stand off plate held to duct in a manner so as not to interfere with the operation of the damper blade. Hardware for the manual volume dampers shall be as follows:

Duct diameter	Shaft size	Quadrant
All sizes	per manufacturer	Ventlok #555/560

E. On uninsulated rectangular ducts, equip dampers with heavy duty locking quadrant and one close end gasketed damper bearing The end bearing be mounted on a 4" x 4" x 1/8" plate held to duct in a manner so as not to interfere with damper blade operation. The locking quadrant shall be mounted on a 2" x 3" x 1/8" standoff plate held to duct in a manner so as not to interfere with the operation of the damper blade. Hardware for the manual volume dampers shall be as follows:

Duct dimension	Shaft size	Quadrant	Bearings
Up to 18 inches	3/8"	Ventlok #555/560	Ventlok #609
19" & larger	½"	Ventlok #555/560	Ventlok #609

F. On insulated round ducts, equip dampers with heavy duty locking quadrant. The locking quadrant shall be mounted on an 8" x 8" x 1/8" stand off plate. The

standoff shall be the insulation thickness plus ½" . The plate shall be held to duct in a manner so as not to interfere with the operation of the damper blade. Hardware for the manual volume dampers shall be as follows:

Duct diameter	Shaft size	Quadrant	Bearings
All sizes	per mfg'r	Ventlok #555/560	Ventlok #607&609

G. On insulated rectangular ducts, equip dampers with heavy duty locking quadrant and one close end gasketed damper bearing. The locking quadrant shall be mounted on an 8" x 8" x 1/8" stand off plate. The standoff shall be the insulation thickness plus ½". The end bearing be mounted on a 4" x 4" x 1/8" plate. Both plates shall be held to duct in a manner so as not to interfere with damper blade operation.. Hardware for the manual volume dampers shall be as follows:

Duct dimension	Shaft size	Quadrant	Bearing
Up to 18 inches	3/8"	Ventlok #555/560	Ventlok #607&609
19" & larger	½"	Ventlok #555/560	Ventlok #607&609

H. Cable operated dampers (COD) shall be provided where indicated on plans, and/or where required due to damper location above/behind finished construction, where access to damper would require access door in finished construction. Rectangular dampers shall have opposed blade action. Dampers shall be equipped with internally controlled operators and cable. Cable shall terminate at face of outlet.

Manufacturer	Model
Anemostsat	OB-ASL
Young Regulator	830A-CC w/270-275 operator

I. Volume extractors shall be used where radius tap or split is not possible or where square elbows inlet and outlet throat radii vary by more than 15%.

Manufacturer	Model
Titus	AG-45 /AG-225

2.06 FIRE DAMPERS - DYNAMIC

A. Provide dynamic fire dampers with fusible links in all fire rated partitions, with ratings to conform to fire rating of construction where installed. Blades are to be of interlocking design mounted in a frame having two folder guides that serve as stops. Both frame and blades are to be of galvanized steel construction. Dampers shall be vertical or horizontal with blades out of the air stream. Damper shall be designed to close against a velocity and pressure per UL 555. Damper shall be constructed, tested, and labeled in accordance with the current edition of UL-555 Standard for Fire Dampers. Units with blades in the air stream shall be utilized only when space limitations preclude used standard damper and the engineer approves each specific instance.

B.

Manufacturer:	Model:
Air Balance Inc.	Series D19, D19
Greenheck	Series DFD
Imperial	Series ??
Prefco Products	Series 5500
Ruskin	Series DIBD2, DIBD23

2.07 COMBINATION SMOKE/FIRE DAMPER - AIRFOIL BLADE - EXTERNAL RESET

A. Damper to be combination UL classified fire damper and UL listed Class I smoke damper. Unit including operator shall be rated for 350^{o}F.

B. Blades to be double skin airfoil shape 16 gauge galvanized steel construction mounted in 16 gauge galvanized channel. Unit to incorporate flexible blade and jamb seals, bronze or stainless steel bearings, 1/2" axle, blade interconnecting linkage out of air stream, 16 gauge galvanized steel sleeve.

C. Unit shall incorporate re-operable electric temperature sensor, blade end switches (open and closed), and outside the duct mounted UL listed operator. Operator to be compatible with sequence of operation as stated in Section 230923. Provide manufacturer's standard U.L. Listed open - close - reset switch and position pilot lights in unit mounted enclosure. Enclosure shall be capable of being removed for remote mounting to ensure visibility after system installation.

D. Unit shall meet UL 555, UL 555S, and NFPA90A requirements for fire and smoke dampers. Unit shall bear UL label.

E.

Manufacturer:	Model:
Air Balance Inc.	FA1 w/ Sens-O-Therm
Imperial	770, 771 w/ Dual Override
Greenheck	FSD311 w/ TOR
Ruskin	FSD60 w/ TS-150

2.08 SMOKE DAMPER - AIRFOIL BLADE

A. Damper to be UL listed Class I smoke damper. Unit including operator shall be rated for 350^{o}F.

B. Blades to be double skin airfoil shape 16 gauge galvanized steel construction mounted in 16 gauge galvanized channel. Unit to incorporate flexible blade and jamb seals, bronze or stainless steel bearings, 1/2" axle, blade interconnecting linkage out of air stream, 16 gauge galvanized steel sleeve.

C. Unit shall incorporate blade end switches (open and closed), and outside the duct mounted UL listed operator. Operator to be compatible with sequence of

operation as stated in Section 230923. Provide manufacturer's standard U. L. listed open - close - reset switch and position pilot lights in unit mounted enclosure. Enclosure to be capable of being removed for remote mounting to ensure visibility after system installation.

D. Unit shall meet UL 555S, and NFPA90A requirements for smoke dampers. Unit shall bear UL label.

E.

Manufacturer:	Model:
Air Balance Inc.	SA1
Greenheck	SMD311
Ruskin	SD60

2.09 ACOUSTICAL LINING

A. Sound insulation - where indicated on drawings, and within 10 lineal feet of fans, ductwork shall be lined with fiberglass duct liner of minimum 2 lbs. per cubic foot density and covered with a fire resistant black coating that includes an EPA-registered antimicrobial agent bonded to fiberglass. Thickness of liner 1-1/2" in ducts, 2" in fan and outside air plena. Duct called to have thermal insulation, but also indicated on drawings for sound insulation shall receive sound insulation on inside only consisting of 1-1/2" thick fiberglass minimum 2 lbs. density rigid duct liner with fire resistant coating that includes an EPA-registered antimicrobial agent bonded to fiberglass.

B.

Manufacturer:	Model:
Owens Corning	Aeroflex Plus (2# density)
Certainteed	ToughGard Rigid Liner Board (3# density)

2.10 TERMINAL AIR DISTRIBUTING OUTLETS

A. Finishes - all exposed surfaces of terminal air distributing devices shall be finished as scheduled on drawings.

1. Baked enamel - chemically clean all surfaces after fabrication and apply rust resisting primer. Apply two finish coats of baked or heat-dried enamel of color and gloss matching Architect's samples.

2. Aluminum - anodized natural aluminum of uniform appearance and matching Architect's samples.

1. All ductwork and accessories visible through the air inlets and outlets shall be painted flat black.

B. Seal all air outlets around edges with foam rubber gaskets to minimize leakage.

C. Size and type - tabulated on the drawings.

D. Manufacturer:
Anemostat
Metalaire
Titus
Price

2.11 ACCESS DOORS IN WALLS AND CEILINGS

A. At each control and balancing damper in ductwork, at each fire damper and volume box when located above ceiling or inside the wall not accessible by removal of grille or from the air shafts, furnish an access door for installation by the general contractor. Access doors shall be 18" x 18"(minimum) unless otherwise indicated on plans; rigid construction with two hinges and a latch. In plenum ceilings, provide felt between the door and frame to make an air tight seal.

B. Door shall be suitable for flush mounting, prime coated with rust inhibitive paint, concealed frame, flush screwdriver operated locks with metal cams and anchors as required.

C.

Manufacturer:	Model:
Cesco	
J L Industries	
Karp	
Milcor	M

PART 3 - EXECUTION

3.01 RECTANGULAR DUCT CONSTRUCTION - GENERAL

A. Make turns in main duct runs affecting the static of the system with elbows having a throat radius not less than the width of the duct.

B. Make turns in duct branch runs with elbows having a throat radius not less than one half the width of the duct or with square elbows with internal factory manufactured duct turns of a type acceptable to the Engineer.

C. Low and medium pressure ducts shall be constructed in a substantial and airtight manner with "Pittsburgh" and double locked longitudinal seams, properly hammered down. Other seams shall be SMACNA tables.

D. Make transitions and reducing sections of sufficient length to maintain the angle of deflection of any side less than 20 degrees.

E. Cut sheet metal screws extending inside accessible casing to be smooth and flush with inside of duct.

F. Make airtight, caulked connections between metal ducts and grilles or masonry.

G. Insulate joints between non-ferrous and galvanized iron materials with non-ferrous and galvanized iron angles separated with tar paper strips and fastened with non-ferrous stove bolts.

3.02 DUCT ACCESSORIES, AND HARDWARE

A. Provide access doors to all equipment. Make doors not less than 16" x 16" where not otherwise sized on the drawings. Provide rigid pan construction with two hinges and latch. Provide access on entering and leaving sides of coil and heater sections, and at leaving side of volume boxes. Reinforce duct openings with angle iron frame. Where ducts are insulated, frame is to be raised to surface acting as an insulation stop. Provide felt between door and duct to make airtight seal when locked. Door shall be the double wall insulated type.

B. Latches similar to Ventfabrics, Inc. No. 100 for small doors and No. 310 where physical access is possible. Window latch type hardware is specifically prohibited except where the door swing for a hinged door is restricted by the hung ceiling or some other obstruction.

C. Provide 8" x 8" frame around damper quadrants in insulated ducts for insulation stop, of same height as insulation thickness.

D. Fan and unit connections - 30 oz. neoprene coated cloth connection with 2" clear distance, double wrapped, securely strapped to fan and cut and sewn airtight. Provide in each connection, including mixing box discharge.

3.03 DUCT SUPPORT

A. Rectangular ducts below 30 inches in width shall be hung with 1" x 1/8" galvanized strap iron bent 1" under bottom side of the duct and fastened to the duct with sheet metal screws using one on underside and not less than 2 screws per side and as many more needed so that they are no greater than 6" centers.

B. Rectangular ducts above 30 inches in width shall be hung with galvanized rods fastened to galvanized 1" angles running under the ducts as per detail.

C. Structural attachment of hanging rods and straps to be per detail. Friction type beam attachments for rod or strap hangers is not acceptable. Attachment to metal deck tabs is also not acceptable (refer to detail on plans).

D. Provide hangers on not greater than 8 feet centers.

E. Provide 18 gauge galvanized sheet metal escutcheon plates attached to ducts and on both sides around all exposed ducts passing through partitions, where visible, except within equipment rooms.

F. Provide 2" galvanized ground angles secured to floor on all ducts passing through floors.

3.04 BRACING OF RECTANGULAR DUCTS

A. Ducts shall be reinforced per SMACNA HVAC Duct Construction Standards 1995 edition Tables 1-5 through 1-13M.

B. Tie rods shall not be used.

3.05 ROUND AND FLAT-OVAL DUCTS

A. Round ducts with fittings and accessories are to be machine made, spiral type welded, factory manufactured by United Sheet Metal Co., or another acceptable to the Architect.

B. Make duct sections not longer than 20'-0".

C. Make elbows with welded sections using 5 pieces for 90 degree and 3 pieces for 45 degree turns and having a center line radius of one times the diameter of the duct.

D. Make joints in ducts with inside couplings not less than 6" long and seal joint with Minnesota Mining No. EC 800 adhesive or equal as recommended by the Supplier. Butt ends of duct tight to coupling bead.

E. Hang and encircle all round ducts with l" x l/8" galvanized strap iron. On ducts below 10 ft. circumference, clamp strap iron at top and hang with single rod. Above 10 ft. circumference, clamp strap iron on both sides and hang with 2 rods. Provide hangers on not greater than 8 ft. centers unless noted otherwise on drawings.

F. Make all reducers and reducing fittings concentric and of sufficient length to maintain the angle of deflection of the perimeter below 15 degrees.

G. Make all other fittings including, rectangular to round transitions, access doors with sleeves, volume dampers, and fire damper to conform to manufacturer's standards.

H. Where ducts pass through floors use short length of duct for sleeve. Provide couplings and temporary caps at both ends.

I. Where ducts pass through walls provide sleeves using a coupling one size larger than duct and of length to conform to the thickness of the finished wall. Pack angular spaces with fiberglass insulation.

J. Factory, cut, reinforce, and provide flanges on main ducts for grille and branch connections.

3.06 TURNING VANES

A. Turning vanes shall be double wall construction of minimum 24 gauge galvanized metal. Each vane shall be securely riveted or welded to minimum 22 gauge runner or directly to duct.

B. Turning vanes shall have 2" inside radius spaced 2-1/8" apart through 36" wide duct. Vanes in elbows larger than 36" shall have a 4 1/2" radius and be spaced 3 1/4" apart.

C. Vanes shall be installed in sections to reduce unsupported length for duct depths exceeding 60".

3.07 TEST CONNECTIONS

A. On the discharge duct from each air handling unit downstream at least 5'-0" from unit if duct is accessible, or closer to unit if necessary, install a #699 Ventlock instrument test hold device for balancing and testing of system.

3.08 ACOUSTICAL LINING

A. Install sound insulation over adhesive, on welding pins not more than 12" O.C. with a minimum of two rows per side. Secure lining to pins with speed washers or clips. Apply 4" continuous strip of adhesive along edges at all joints and apply 50% coverage of adhesive between joints. Seal and caulk all joints between boards with adhesive at corners of ducts.

B. Interrupt lining at fire dampers. Insulate exterior of duct at liner interruption if duct requires insulation. Refer to Section 230700.

C. Duct mounted items such as dampers, turning vanes, and coils shall be installed on a continuous circumferential hat section of height equal to liner thickness and width to accommodate item. Provide liner section behind hat section or provide external duct insulation.

D. Provide continuous circumferential sheet metal protection nosing at leading edges of lining on all lined duct sections.

3.09 COORDINATION AND COMPLETION

A. Conform to all applicable provisions of Section 230000 and coordinate with the requirements of the other mechanical work specification sections to provide complete operating systems.

3.10 AIR BALANCE

A. Balance all new air systems and those designated existing air systems to the quantities shown with the following tolerances:

Fans:	Design volume plus 5%
Outlets:	Design volume plus 5%
Leakage:	3% maximum.

B. Balance in accordance with ASHRAE, AABC or NEBB procedures and submit all readings.

C. Air system balancing is to be performed by a professional organization, other than the installing contractor, qualified by experience and practice to perform this service. Submit evidence of qualifications, balancing procedures, and report forms for approval prior to start of work.

D. Provide one extra set of drive sheaves per fan as part of the system balancing. Sheaves shall be installed as directed by the balancing subcontractor to achieve design CFM at the minimum RPM with an allowance for filter loading.

E. Submit three bound copies of the air balance report to the Engineer. Balance Report to include the following data for each fan system (supply, return, relief and exhaust).

1. System designation and location.
2. System description including areas served.
3. Manufacturer, model number, size designation, class and arrangement.
4. Supply/return/outside air CFM - Design vs. Actual (unit air quantities to be determined by duct traverse not sum of outlets - Submit data of traverse/minimum traverse points = 16 - max. distance between traverse points = 6")
5. Unit suction and discharge static pressure - design vs. actual.
6. Individual unit component static pressure drops (coils, filters, dampers)
7. Motor manufacturer, frame, horsepower, volts, phase, hertz and RPM.
8. Motor AMPS - design vs. actual.

9. Fan RPM
10. Sheave and belt data.
11. Air outlet number, type, size, Ak, design CFM and velocity, intermediate velocity readings, final CFM and velocity.
12. Reduced plans with air outlets cross-referenced to number.
13. CFM, static pressure drop, (CFM and static pressure at minimum setting for VAV boxes) for all duct mounted items such as coils, VAV boxes, filters, induction units.

3.11 AIR DUCT LEAKAGE TEST

A. Supply ductwork from the supply air fan to the terminal boxes shall be subject to inspection and leakage testing by the testing, adjusting, and balancing (tab) agency.

B. The duct system testing shall be performed before the installation of duct insulation and ceilings. Testing shall be conducted at the design pressure of the ductwork being tested. Duct leakage test shall be coordinated with the various contractors through the HVAC contractor. The HVAC contractor shall prepare a schedule for testing indicating specific dates and procedures. The owner and architect shall be notified a minimum of two (2) weeks before testing is performed.

C. Procedures for conducting the leakage test shall be in accordance with SMACNA air duct leakage test manual. Procedures shall be submitted to the architect for approval prior to actual testing.

D. Maximum leakage shall not exceed the requirements for Leakage Class 6.

E. Leakage for non-duct components such as fire, smoke, and volume dampers, and terminal boxes is an integral part of the overall system leakage, and these components shall be included in the duct leakage tests.

F. Ductwork failing to meet the maximum leakage criteria shall be resealed and or reconstructed as required.

G. The tab contractor shall submit a report on the leakage test. The report shall include an accurate description of the test procedure and results, including recommendations for any remedial action required to meet the specified leakage criteria. Copies of certified calibration data for the leakage test apparatus shall be provided as part of the test report.

3.12 WIRING OF COMBINATION FIRE/SMOKE AND SMOKE DAMPERS

A. The Division 23 mechanical contractor shall be responsible for all wiring of combination fire/smoke and smoke dampers, including all damper power as well as all damper control wiring.

B. Obtain sources of electrical power as directed on the electrical plans, in the electrical specifications, and herein. Provide such power wiring from the source of power to the dampers and associated controls as required for a complete system installation.

C. Confer with the Division 23 temperature control contractor to ensure damper control sequences are in accordance with the sequences of operation outlined in Section 230923.

D. The Division 23 mechanical and temperature control contractors shall be responsible for ALL damper control – this includes life safety shut-down and control, smoke purge / exhaust sequence control, as well as standard operation for specified temperature control sequences.

E. Refer to Section 230923 for additional requirements.

3.13 DUCT MOUNTED SMOKE DETECTORS

A. Coordinate with Electrical Contractor for quantities of duct mounted smoke detectors.

B. Exact locations of duct mounted smoke detectors shall be determined by the Mechanical Contractor and indicated on sheet metal shop drawings.

C. Duct mounted smoke detectors shall be furnished and wired by the Electrical Contractor. Installation of the duct mounted smoke detectors in the ductwork shall be by the Mechanical Contractor.

END OF SECTION 23 30 00

SECTION 23 50 00

HEATING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the Contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Boiler
2. Burner and combustion controls
3. Pre-fabricated chimney
4. Heating plant accessories
5. Operating instruction including sequence of starting, stopping and shutdown.
6. Readings required on all indicating instruments for proper operation.
7. System maintenance requirements not covered by equipment manufacturer's instructions.
8. Coordinate with the temperature control requirements in preparing these diagrams

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000. Produce and maintain ventilation and air conditioning under operating criteria.

PART 2 - PRODUCTS

2.01 HEATING - GENERAL

A. Match capacities, characteristics and dimension of all components to make a completely compatible system over its entire operating range.

B. Equipment shall be constructed and rated in accordance with AGA and IBR standards and applicable provisions of the ASME code.

C. Equipment shall comply with all state and local codes governing the performance of gas burning equipment, including the organizations listed in Section 230000.

2.02 PULSE BOILER

A. Unit shall utilize pulse combustion technology complete with boiler fittings and automatic controls. The boiler and wiring shall be completely factory assembled as a self contained unit. Each boiler shall be neatly finished, thoroughly tested and properly packaged for shipping. Boiler design and construction shall be in accordance with ASME Code for hot water heating boilers with a maximum working pressure of 160 PSI. Boiler shall comply with CSD-1 Code requirements.

B. The boiler shall have no minimum flow or minimum return water temperature requirements. The boiler shall utilize a firetube type design, utilizing principles of pulse combustion. The boiler, due to the nature of pulse combustion, shall be self-venting and self-aspirating, requiring no forced or induced draft fan to supply air to maintain combustion after ignition. During operation maximum amp draw to maintain combustion shall not exceed 0.5A. Adequate openings shall be provided for access to the water side of the boiler.

C. The combustor and exhaust pipes shall be constructed of SA-312 Grade 316 stainless steel. The vessel shall be SA-53B ERW pipe or SA-285 Grade C plate. The heads shall be SA-516 Grade 70 plate. The pressure vessel shall be fully insulated with 2” of high temperature insulation.

D. At the scheduled operating capacity and conditions, the boiler shall maintain a fuel to water efficiency of **92.5%**. The maximum boiler efficiency shall be 98% when fed with return water lower than 100^0 F.

E. The Pulse Combustion Boiler shall meet A.G.A./.C.G.A. approval as a direct vent boiler, with a conventional stack or chimney not required. The boiler shall have the combustion air intake supply ducted in from the outside. Exhaust venting and combustion air venting shall be constructed from AL-29-4C.

2.03 PULSE BOILER CONTROL EQUIPMENT

A. The flame safeguard shall be a Fulton RM7865. This control must supply a 35 second pre and post purge. The control shall maintain a running history of operating hours, number of cycles and most recent six failures. This control shall have the capability to be connected to a keyboard display module which will retrieve that information. A diagnostic display module shall be mounted to the front door of the boiler and clearly provide service technicians with boiler operating information.

B. Each boiler shall be equipped for a modulated gas input. Fuel flow shall be controlled by a valve in the fuel train. Air flow shall be controlled by a 316-L butterfly valve located in the exhaust vent. Both valves will be connected to a modulation motor which is controlled from a 4-20 ma signal from a microprocessor based temperature controller. Turn down shall be 5:1.

C. Each boiler shall be capable of operating with a gas pressure between 10”W.C. and 1psi at the inlet to the boiler gas train.

D. The pulse combustor location shall be such that all combustor assembly components are located within water backed areas. Pulse combustion controls shall be on/off operative type and are to include:

1. Operating Temperature Controller for automatic start and stop of the pulse combustor.
2. High limit temperature controller (manual reset)
3. One Low Water Cutoff Probe in boiler shell
4. Air safety switch to prevent operation until sufficient pre-purge air is assured
5. Proof of flame switch to prove combustion.

E. All controls are to be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to A.G.A./C.G.A. and UL requirements. Electric power supply shall be 120/1/60.

2.04 ACCESSORIES

A. Boiler shall be supplied with the following:

1. Condensate Drain Kit

2. Diagnostic Display Module (factory mounted)
3. Pressure and Temperature Gauge
4. Boiler Isolation Dampers
5. Water and gas flex connectors
6. Intake and exhaust mufflers
7. Spring Isolators

2.05 MODULATION CONTROL SYSTEM

A. BOILER manufacturer shall supply, as part of the boiler package, a completely integrated Modulating Control System to control all operation and input of the multiple boiler plant.

B. The system shall be comprised of a microprocessor based control, utilizing relays for on/off operation and a 4 to 20 mA signal for modulation of header temperature and sequential firing.

C. The controller shall have the ability to vary each module input throughout its full firing range, to maximize the condensing capability of the module and the entire plant without header temperature swings. The controller shall be PID type for accurate temperature control with excellent frequency response.

D. The Fulton control shall provide contact closure for automatic adjustable heat start circuit for plant activation and have contact closure for auxiliary equipment such as pumps and auxiliary loops.

E. The modulating control system will operate on an adjustable inverse ratio in response to the outdoor temperature to control the main header temperature outlet to $+/-2^{0}$F. Maximum efficiency shall be achieved at a minimum firing input. The control will provide equal firing time of each module.

F. Reset ratio shall be fully field adjustable utilizing a 6 point heating curve in operation. The controller shall have LCD display for monitoring of all sensors and % of modulation on one screen.

G. Connection between the MCS and individual units shall be twisted pair low voltage wiring to internal terminal strips for easy installation. The system shall allow units to remain at low fire to maintain load. Fulton pulse units are most efficient at low fire. If the load cannot be achieved the control will modulate the units up to the required output.

H. Provide contacts for remote start by DDC system and contact for remote general alarm to DDC system for any alarm.

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in accordance with the manufacturer's recommendations.

END OF SECTION 235000

SECTION 23 60 00

REFRIGERATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. The installation and equipment is to conform to ANSI B 9.l Safety Code for Mechanical Refrigeration.

1.03 SUBMITTALS

A. Procedure: Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Chillers

C. System maintenance requirements not covered by equipment manufacturers' instructions.

1.04 SYSTEM TESTING

A. Perform operating tests and instruct Owner's personnel as specified in Section 230000. Produce and maintain refrigeration effect under operating criteria determined in advance by agreement with the Architect.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Construct all apparatus of materials suitable for the conditions encountered during operation.

B. Construct all equipment in accordance with the requirements of the local and state codes. Construct all pressure vessels in accordance with the ASME Code for unfired pressure vessels. Pressure vessels shall bear the code stamp.

C. All factory applied acoustical and thermal insulation, including facing and adhesive, to be fire-resistant or non-combustible, and shall conform to the requirements of NFPA and local codes.

D. Mount grease fittings directly on bearings unless the bearings are not visible or inaccessible. Then provide easily accessible extensions to bearing lubrication fittings.

E. Balance all fan wheels and other moving components statically and dynamically. Drill all fan shafts on the center line to receive a tachometer point.

F. Match and balance all system components to achieve compatibility of equipment for satisfactory operation and performance throughout the entire operating temperature and control range.

G. Provide all controls, wiring, piping, valves, tubing, accessories and other components necessary to make a complete operating system.

H. All refrigeration equipment shall comply with the applicable provisions of the ASME Code and American Standard Safety Code for Mechanical Refrigeration ASA-B 9.l, the requirements of all regulating bodies having jurisdiction and the recommendations of the equipment manufacturer.

I. Electrical operating and safety controls shall be 120 volt or less. The control circuit shall have a grounded neutral with all safety controls in the ungrounded leg.

J. All items of refrigeration equipment shall be shipped complete with a holding charge or refrigerant and oil.

K. Chillers shall be shipped with a factory charge of refrigerant HCFC-123 or R-134a. Chillers using R-11, R-12 or R-22 shall not be acceptable.

2.02 CHILLER: SINGLE PACKAGE AIR COOLED

A. Factory assembled single piece unit including furnished complete with helical rotary compressors, shell and tube evaporator, air-cooled condenser, electronic expansion valves and microprocessor control panel. Total unit shall be UL certified and include the UL label. The unit shall be designed for outdoor application. The unit shall be rated in accordance with AHRI Standard 550/590-2003.

B. The chiller shall be constructed using semi-hermetic helical rotary screw compressors with independent circuits. Statically and dynamically balance rotating parts. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation. Provide compressor with automatic capacity reduction equipment consisting of capacity control slide valve. Compressor must start unloaded for soft start on motors. Provide constant speed 3600 rpm for 60Hz compressor motor, suction gas cooled with robust construction and system design protection, designed for across-the-line or wye-delta starting. Furnish with starter. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating. Provide sound absorbing panels to attenuate compressor noise. Compressors shall be individually resiliently mounted to the unit frame using isolators with a minimum efficiency of 95%.

C. Warranty for the compressors shall be five (5) years.

D. The evaporator shall be designed, tested, and stamped in accordance with ASME code for a refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig. Insulate the evaporator and water boxes with a minimum of 3/4 inch (K=0.26) insulation. If field installed the additional money to cover this in the field should be included in the bid. Evaporator heat tape shall be factory installed and shall protect unit down to -20 F. Contractor shall wire separate power to energize heat tape and protect cooler while chiller is disconnected from the main power. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets. Provide ability to remove evaporator tubes from either end of the heat exchanger. Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cutout sensors. Water connections shall be grooved pipe. Evaporator shall have only one entering and one leaving connection. If manufacturer provides 2 separate evaporators, contractor shall provide manifold and pressure gauges to ensure equal flow is provided to each evaporator. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

E. Provide vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Entire fan assembly shall be statically and dynamically balanced and fan assembly shall be either painted or zinc coated steel. Fan guard shall be either PVC, chrome, or zinc coated. Provide TEAO (Totally Enclosed Air Over) fan motors with permanently lubricated ball bearings. Chiller shall be able to operate in ambient conditions down to 25 degrees F. Construct condenser coils of aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 506 psig. Provide factory mounted, louvered, "architecturally pleasing" guard panels. The maximum louver opening is to be 6” or less. Panel louvers shall cover condenser, evaporator and compressor sections so all are hidden from sight. Wire screens or wire mesh will not be allowed.

F. House components in a galvanized steel frame and mounted on welded structural steel base. Hot-dip galvanized steel frame coating shall be Underwriters Laboratories Inc. (UL) recognized as G90-U, UL guide number DTHW2. Unit panels and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays. Paint system shall meet the requirements for outdoor equipment of Federal Government Agencies. Mount starters and Terminal Blocks in weatherproof panel provided with full opening access doors. If a disconnect or circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of unit indicating if power is on or off. Casings fabricated from steel that do not have a Zinc coating conforming to ASTM A 123 or ASTM A525 shall be treated for the prevention of corrosion with a factory coating or paint system. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B 117. Each specimen shall have a standard scribe mark as defined in ASTM D 1654. Upon completion of exposure, the coating or paint system shall be evaluated and rated in accordance with procedures A and B of ASTM D 1654. The rating of failure at the scribe mark shall be not less than six (average creepage not greater than 1/8 inch). The rating of the unscribed area shall not be less than ten (no failure). Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness. For each compressor provide a wye-delta starter. Delta-Delta and Solid State Starters shall be unacceptable because they accomplish a smaller reduction in inrush than Y-delta. Compressors utilizing variable speed drive design shall be IEEE 519-1992 compliant. They shall include as standard integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5-percent as measured at the VSD input. If optional active filters are used to meet the less than or equal to 5% TDD, then the losses associated with the filter shall be included in the chiller performance on the selection.

G. All units shall have 2 refrigeration circuits to provide redundancy, each with one or two (manifolded) compressors on each circuit. Single refrigerant circuit chillers are not acceptable.

H. Provide for each refrigerant circuit:

1. Liquid line shutoff valve.
2. Suction Service Valve
3. Filter (replaceable core type).
4. Liquid line sight glass.
5. Electronic or thermal expansion valve sized for maximum operating pressure.
6. Charging valve.
7. Discharge and oil line check valves.
8. High side pressure relief valve.
9. Full operating charge of HFC-134a and oil for packaged units only. Units with remote evaporator option selected will ship with an oil charge and a nitrogen holding charge.

I. Capacity Modulation: Provide capacity modulation that includes linear unloading to maintain close leaving water temperature control. Unit shall be capable of operation down to 20%.

J. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer. Controls shall include the following readouts and diagnostics:

1. Phase reversal/unbalance/single phasing and over/under voltage protection.
2. Low chilled water temperature protection.
3. High and low refrigerant pressure protection.
4. Load limit thermostat to limit compressor loading on high return water temperature.
5. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize unit efficiency.
6. Display diagnostics.
7. Oil pressure control based off of maintaining system differential pressure.
8. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.

K. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer and a single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.

1. The unit controller shall utilize the following components to automatically take action to prevent unit shutdown due to abnormal operating conditions which will perform as follows:

a. High pressure switch that is set 20 PSIG lower that factory pressure switch that will automatically unload the compressor to help prevent a high pressure condenser control trip. One switch is required for each compressor and indicating light shall also be provided.

b. Motor surge protector that is set at 95% of compressor RLA that will automatically unload the compressor to help prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.

c. Low pressure switch that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One switch is required for each compressor and indicating light shall also be provided.

L. In the above case, the chiller will continue to run in an unloaded state, and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset will be required. Once the "near-trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.

M. Provide the following safety controls with indicating lights or diagnostic readouts.

1. Low chilled water temperature protection.
2. High refrigerant pressure.
3. Low oil flow protection.
4. Loss of chilled water flow.
5. Contact for remote emergency shutdown.
6. Motor current overload.
7. Phase reversal/unbalance/single phasing.
8. Over/under voltage.
9. Failure of water temperature sensor used by controller.
10. Compressor status (on or off).

N. Provide the following operating controls:

1. Eight (8) or more step leaving chilled water temperature controller which cycles compressors and activates cylinder unloaders or slide valve based on PI algorithms. If manufacturer is unable to provide at least 8 steps of unloading, providing hot gas bypass shall be required.

2. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer

is included, hot gas bypass shall be provided to insure accurate chilled water temperature control in light load applications.

3. Chilled water pump output relay that closes when the chiller is given a signal to start.

4. Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trip outs.

5. High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.

6. Compressor current sensing unloader unit that unloads compressors to help prevent current overload nuisance trip outs.

7. Auto lead-lag functions that constantly even out run hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor on how to manually change lead-lag on compressors and even out compressor starts and running hours.

8. Low ambient lockout control with adjustable setpoint.

9. Condenser fan sequencing which automatically cycles fans in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing unit efficiency.

O. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:

1. Supply chilled water set point adjustment from LCD input
2. Entering and leaving chilled water temperature output
3. Percent RLA output for each compressor
4. Pressure output of condenser for circuits one and two
5. Pressure output of evaporator for circuits one and two
6. Ambient temperature output
7. Voltage output
8. Current limit set point adjustment from LCD input.
9. Alarm indicating light and relay
10. Supply chilled water set point input from BMS
11. On/Off command input from BMS

P. Digital Communications to BAS system shall consist of a LonMark certified LonTalk interface supporting all standard points in the LonMark chiller profile. Certification by LonMark is only acceptable if listed on lonmark.org web listing.

Q. Digital Communications to BAS system shall consist of a BACnet interface.

R. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.

S. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

T.

Manufacturer:	Model:
Trane	RTAC
York	YCAV
McQuay	AGS

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in conformance with manufacturer's recommendations.

3.02 FIELD TESTS - PERFORMANCE

A. The manufacturer of the equipment shall perform all field testing and final adjustment of the refrigeration apparatus in accordance with provisions of the applicable ASHRAE Standards.

B. Compile and certify the following data as applicable to the equipment being tested.

Outdoor air temperature
Temperature of chilled water - in and out
Temperature of condenser water (or glycol) - in and out
Chilled water flow - GPM
Condenser water (or glycol) flow - GPM
Pressure drop through chillers
Pressure drop through condensers
Condensing temperature
Operating kilowatts from measured voltage, amperes, power factor.

C. Should any part of the apparatus or system fail to meet the contract requirements, adjust, repair or replace any and all defective or inoperative parts and, on completion, again conduct the complete performance tests.

3.03 INSTALLATION, SUPERVISION AND INSTRUCTION

A. The manufacturer shall provide a competent engineer for a total of three eight-hour days, (straight time basis) not necessarily consecutive, for the instruction of the Owner's personnel. The instruction period shall start after the test period.

B. Provide three charts of equipment lubrication and maintenance schedules mounted on 1/4" masonite and covered with heat bonded clear plastic laminate.

C. Provide a set of start and stop instruction mounted on 1/4" masonite and covered with heat bonded clear plastic laminate at each machine.

END OF SECTION 23 60 00

SECTION 23 70 00

AIR HANDLING AND TREATMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and applicable provisions of the Contract, including General and Supplementary Conditions, Division 1 - General Requirements, and the General Provisions, Section 230000, govern the work of this Division.

B. Requirements given herein may be affected by other related requirements of the project specification. Correlation of the contract requirements is the responsibility of the contractor.

1.02 REFERENCES

A. Perform the work in accordance with the requirements of Section 230000, General Provisions, and with the provisions of all applicable codes and laws.

B. The installation and equipment is to conform to ANSI B9.1 Safety Code for Mechanical Refrigeration.

C. Air Moving and Conditioning Association (AMCA) Standards - Air performance of all air moving devices, shall be rated in accordance with AMCA Standard Test Code 2l0 and shall be licensed to bear the AMCA certified rating. Sound ratings specified in Section 230000 shall be obtained in accordance with the AMCA Standard 300. They shall be published in accordance with AMCA Standard 30l, and the products should bear the AMCA sound certified ratings seal.

D. The quantity and performance criteria for each type of equipment is listed in the equipment schedules.

1.03 SUBMITTALS

A. Procedure

1. Prepare and make the submissions listed below and in Section 230000 in accordance with the procedure specified in Section 230000.

B. Shop Drawings

1. Air Handling Equipment and all Related Equipment
2. Fans
3. Fan Performance Curves
4. Heating and cooling coils
5. Filters
6. Variable volume, constant volume, fan terminal units
7. Fan coil units
8. Humidifier
9. Cabinet and Unit Heaters
10. Sound Absorbers

C. System Testing

1. Perform operating tests and instruct Owner's personnel as specified in Section 230000. Produce and maintain ventilation and air conditioning under operating criteria determined in advance by agreement with the Architect.

PART 2 - EQUIPMENT

2.01 GENERAL REQUIREMENTS

A. Construct all apparatus of materials suitable for the conditions encountered during operation.

B. All factory applied acoustical and thermal insulation, including facing and adhesives, sealants and paint, to be fire-resistant or non-combustible, and shall conform to the requirements of NFPA and local codes.

C. Construct all equipment in accordance with requirements of the local and state codes. Construct all pressure vessels that fall within the scope of ASME Code for unfired pressure vessels to conform to the code and bear the code stamp. Furnish three copies of National Board Inspection and Test Report.

D. Match and balance all system components to achieve compatibility of equipment for satisfactory operation and performance throughout the entire operating temperature and control range.

E. Provide all controls, wiring, piping, valves, tubing, accessories and other components necessary to make a complete operating assembly.

F. Test and rate all fans in accordance with the standards of AMCA. All fans must bear the AMCA rating seal.

G. Mount grease fittings directly on bearings unless the bearings are not visible or inaccessible. Then provide easily accessible extensions to bearing lubrication fittings.

H. Balance all fan wheels and other moving components statically and dynamically. Drill all fan shafts on the center line to receive a tachometer point.

I. Submit to the Engineer for approval complete curves of fan performance at the operating speed.

J. Provide coil covers on all coil headers which are installed outside of the air stream.

K. All filters shall be U.L. Class I.

L. Certify unit performance in accordance with ARI standard 410-72.

M. Submit to the Engineer for approval complete sound power data at the operating speed.

N. Motors to be premium high efficiency type with guaranteed minimum efficiency rated in accordance with IEEE standard 112, method B. Refer to Specification Section 230513 for required motor efficiencies and acceptable manufacturers.

O. Fans scheduled for variable speed duty shall be equipped with motors compatible with and specifically designed for variable speed operation. Coordinate with the manufacturer of the variable speed drive as specified in Section 230513.

2.02 AIR HANDLING UNITS: INDOOR (AHU-1, RF-1, AHU-2, RF-2, AHU-3, RF-3, AHU-4, RF-4, AHU-5 & OAU-1)

A. UNIT CASING

1. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

2. Casing performance – Casing air leakage shall not exceed leak class 9 (C_L = 9) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft^2 of casing surface area) = C_L X $P^{0.65}$.

3. Air leakage shall be determined at 1.25 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

4. Under 55°F supply air temperature and design conditions on the exterior of the unit of 81°F dry bulb and 73°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.

5. Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8" w.g., whichever is less, and shall not exceed 0.0042" per inch of panel span (L/240).

6. Floor panels shall be double-wall construction and designed to support a 250-lb load during maintenance activities and shall deflect no more than 0.0042" per inch of panel span.

7. Unit casing panels shall be 2" double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.

8. Unit casing panels (roof, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 Hr*Ft^2*°F/BTU.

9. Unit casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

10. Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.

11. Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.

12. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

B. ACCESS DOORS

1. Access doors shall be 2" double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.

2. All doors downstream of cooling coils shall be provided with a thermal break construction of door panel and door frame.

3. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.

4. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.

5. Handle hardware shall be designed to prevent unintended closure.

6. Access doors shall be hinged and removable without the use of specialized tools to allow.

7. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions.

8. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.

9. All doors shall be a minimum 60" high when sufficient height is available, or the maximum height allowed by the unit height.

10. Multiple door handles shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit.

11. A single door handle shall be provided for each door linking multiple latching points necessary to maintain the specified air leakage integrity of the unit.

12. A shatterproof window shall be provided in access doors where indicated on the plans.

C. PRIMARY DRAIN PANS

1. All cooling coil sections shall be provided with an insulated, double-wall, stainless steel drain pan.

2. The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer's requirements. See section 2.07, paragraph F through H for specifications on intermediate drain pans between cooling coils.

3. The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

4. All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted.

5. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2” beyond the base to ensure adequate room for field piping of condensate traps.

6. The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

7. Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.

8. Drain pans shall be provided for heating coils, access sections, and mixing sections as indicated in the plans.

D. FANS

1. Fan sections shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.

2. Provide fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. If fans are not factory-tested for vibration and alignment, the contractor shall be responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

3. Belt-driven fans shall be provided with grease lubricated, self-aligning, anti-friction bearings selected for L-50 200,000-hour average life per ANSI/AFBMA Standard 9. Lubrication lines for both bearings shall be extended to the drive side of the AHU and rigidly attached to support bracket with zerk fittings. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

4. All fans, including direct-drive plenum fans, shall be mounted on spring isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Unit sizes up to nominal 4,000 cfm shall have 1-inch springs. Unit sizes larger than nominal 4,000 cfm shall have 2-inch spring isolators. A flexible connection (e.g. canvas duct) shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.

5. Fan sections containing multiple fans shall be provided as indicated on the schedule and drawings. Each fan shall operate in parallel to each other fan in the array. The fans shall be SWSI plenum type with high efficient AF blades. Fans shall be direct-driven. Fan wheels shall be aluminum. The Hp characteristic of the fans shall be non-overloading.

6. Fan sections containing multiple fans shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.

7. Fan airflow measurement systems shall be provided as indicated on the schedule and drawings to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +/- 5 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with a 2-10 VDC output. Signal shall be proportional to air velocity.

8. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.

E. MOTORS AND DRIVES

1. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.

2. Motors shall meet or exceed all NEMA Standards Publication MG 1 – 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.

3. Fan Motors shall be heavy duty, Premium Efficiency ODP, exceeding the EPAct efficiency requirements.

4. Belt-driven fan sections with single fans shall use 4-pole (1800 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads.

5. Direct-driven fan sections shall use 2-pole (3600 rpm), 4-pole (1800 rpm), or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads. Multiple fan selections utilizing 8-pole (900 rpm) motors are unacceptable due to motor inefficiency, cost, and replacement lead times.

6. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

7. V-Belt Drive shall be 1.5 times the motor nameplate. Drives 20 hp and larger or any drives on units equipped with VFDs shall be fixed pitch.

8. All fans with fixed-pitch drives and motors 15 hp and larger shall be equipped with multiple belt drives.

9. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in start up and service personnel in maintenance:

   a. Fan and motor sheave part number
   b. Fan and motor bushing part number
   c. Number of belts and belt part numbers
   d. Fan design RPM and motor HP
   e. Belt tension and deflection
   f. Center distance between shafts

F. COILS

1. Coils section side panels shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.

2. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

3. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

4. Construct coil casings of stainless steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

5. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the

manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.

6. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the primary drain pan.

7. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.

8. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

G. HYDRONIC COILS

1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.

2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.

3. Headers shall be constructed of round copper pipe or cast iron.

4. Tubes shall be 1/2 or 5/8 inch O.D., minimum .035 inch thick copper. Fins shall be aluminum.

H. FILTERS

1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement.

2. Filter type, MERV rating, and arrangement shall be provided as defined in project plans and schedule.

3. Manufacturer shall provide one set of startup filters.

4. Each filter section shall be provided with a factory-installed, flush-mounted Dwyer dial-type differential pressure gauge piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Filter sections consisting of pre- and post-filters shall have a gauge for each.

I. DAMPERS

1. All dampers, with the exception of external bypass and multizones (if scheduled), shall be internally mounted. Dampers shall be premium ultra low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 4 CFM/square foot at three inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being furnished.

J. ACCESS SECTIONS

1. Access sections shall be provided where indicated in the schedule and plans to allow additional access for inspection, cleaning, and maintenance of unit components. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be provided in the AHU manufacturer’s maintenance manual.

K. DISCHARGE PLENUM SECTIONS

1. Plenums shall be provided as indicated in the schedule and plans to efficiently turn air and provide acoustical attenuation. Discharge plenum opening types and sizes shall be scaled to meet pressure drop requirements scheduled and align with duct takeoffs.

2. Discharge plenum panels shall include an acoustical liner where indicated in the schedule and plans to meet acoustical requirements. The liner shall be fabricated from stainless steel perforated material to prevent corrosion and designed to completely encapsulate fiberglass insulation. The perforation spacing and hole size shall be such as to prevent insulation breakaway, flake off, or delamination when tested at 9000 fpm, in accordance with UL 181 or ASTM C1071. Insulation material must be resistant to fungi in accordance with ASTM C1338.

L. TOTAL ENERGY RECOVERY WHEEL SECTIONS

1. Total energy recovery wheels shall be provided as indicated on the schedule and drawings. Wheels shall be integral parts of the AHUs and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable. Mixed air units with economizing shall be constructed with internal bypass dampers such that the pressure drop across the wheel does not increase during economizing. External bypass and multiple duct connections are not acceptable.

2. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.

3. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The adsorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Seals shall be factory set.

4. Wheel drive motor shall be provided mounted in the cassette frame. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. On units that require drive belt tensioners for the wheel belt/motor assembly, the unit manufacturer shall provide at no additional charge to the customer a visual inspection every

four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings.

5. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

6. Access doors shall be provided for the removal of wheel segments. Doors shall be located on all air entering and air leaving sides of wheel to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal. Access doors shall be constructed per Section 2.04.

7. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.

8. Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.

9. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.

M. ACCESSORIES

1. Marine lights shall be provided at each AHU section with an access door. Lights shall be fluorescent type to minimize amperage draw and shall produce lumens equivalent to a minimum 64 W, instant-start bulb. Lights shall be constructed of safety glass. Lights shall be suitable for wet locations.

2. All lights on a unit shall be wired in the factory to a single on-off switch. On outdoor units, the light switch shall be mounted on the casing exterior in a NEMA 4 enclosure next to the fan access door. Lighting circuit(s) shall be wired by the AHU Manufacturer to a common junction box separate from the VFD or

starter so the lights can remain on when the main disconnect to the unit is on or off. A connector plug shall be provided at each shipping split to eliminate field wiring of lights between splits.

3. A 15 amp, 115V GFCI convenience outlet shall be provided by the AHU Manufacturer. On outdoor units, the outlet shall be mounted on the casing exterior in a NEMA 4 enclosure next to the fan access door. The outlet shall be wired by the AHU Manufacturer to the same circuit as the lights.

N.

Manufacturer:	Model/Series:
Trane	PCC
York	Solution XTI
McQuay	Vision

2.03 AIR HANDLING UNIT: ROOFTOP (AHU-6)

A. GENERAL

1. A factory-assembled, vertical return air, vertical down flow discharge air, draw-thru type air handler suitable for exposed outdoor installation in four pipe configuration.

B. CONSTRUCTION

1. Cabinet shall be constructed from the galvanized steel, painted with baked on polyurethane based powder coating with textured finish; gauges per schedule below:

a.	Motor mount	16 ga.
b.	Blower Rails	18 ga.
c.	Cabinet	19 ga.
d.	Drain pan (metal option)	19 ga.
e.	Liner (double wall option)	19 ga.

2. The cabinet shall be constructed from 1” double wall construction shall consist of 1” Exact-O- Kote™ insulation with a minimum 22-gauge galvanized steel liner with no fiberglass insulation exposed to the air stream. Exact-O-Kote® IAQ insulation contains an EPA-registered immobilized antimicrobial agent tested in accordance with ASTM G21 and G22.

3. The cabinet shall be equipped with Type 304 stainless steel drain-pan shall be double-sloped for IAQ Type 304 stainless steel drain-pan, treated externally with antimicrobial/anti-condensation agent.

4. Piping penetrations through the cabinet will be isolated with rubber/plastic grommets or bushings.

5. The unit shall include 100% airside economizer option.

C. FANS

1. Units shall be equipped with belt-driven, double-width fan wheels shall have forward-curved blades and be statically and dynamically balanced. Fans and scrolls shall be of galvanized steel. Removable side panels shall be provided for access to the fan/motor assembly.

D. COILS

1. Unit shall be equipped with chilled water and hot water reheat coils. Coils shall have a working pressure of 400 psig at 200 F. Aluminum fins bonded to the ½" o.d. copper tubes by mechanical expansion.

E. MOTORS

1. Motors shall be NEMA premium efficiency inverter duty rated three phase motors.

F. FILTERS

1. Filters shall be 2" pleated filter(s), MERV-13

G. AIRFLOW MEASURING

1. Provide factory-mounted air flow measuring station at ventilation air intake.

H. MANUFACTURERS

1. MagicAire or approved equal

2.04 FAN: ROOF MOUNTED, VERTICAL CENTRIFUGAL INLINE

A. Roof curb mounted, centrifugal belt drive, upblast, vertical discharge type. Housing shall consist of heavy gauge aluminum construction. All spun parts shall have a rolled bead for added rigidity and shall be specially spun so as to seal the pores of the aluminum providing greater resistance against oxidation and deterioration.

B. The fan wheel shall be all aluminum, heliarc welded, of the centrifugal blower type featuring airfoil blades and a tapered inlet shroud. Wheels shall be statically and dynamically balanced. Inlet cone shall be aluminum and of centrifugal blower type.

C. Motor and drives shall be enclosed in a weathertight compartment, separate from the exhaust airstream. Air for cooling the motor shall be supplied to the motor compartment by way of an air tube from an area free to contaminated exhaust fumes. Motors shall be of the heavy duty, permanently lubricated, sealed ball bearing type.

D. Drives shall be sized for 165% of motor horsepower capabilities and of the cast iron type, keyed to the fan and motor shafts. Variable pitch drives shall be standard. Fan shaft shall be of steel construction, turned, ground and polished to precise tolerances in relationship to the hub and bearings. Drive belts shall be of oil-resistant, non-static, non-sparking type with life expectancy of over 24,000 hours. Bearings shall be flanged and of the permanently lubricated, permanently sealed, ball bearing type capable of over 200,000 hours bearing life. Provide lube lines to external lubrication fittings mounted on the outside of the unit housing.

E. The entire drive assembly and wheel shall be removable, as a complete unit, from the support structure without disassembling the external fan housing. The complete drive assembly shall be mounted on rubber vibration isolation.

F. Accessories

1. Unit mounted disconnect switch
2. 12 Inch high roof curb
3. Anti condensate coating
4. Discharge mounted back draft damper
5. Class B totally enclosed motor
6. Explosion proof motor
7. UL listing

G. Direct drive units shall be of identical construction as belt drive units, except for drives, belts, and fan shaft bearings.

H. Manufacturer: Loren Cook type UCVB or approved equal.

2.05 FAN: CENTRIFUGAL - VENTILATING SET

A. Factory assembled unit with all components and motor mounted on a steel base.

B. Reinforced steel volute, air tight mounted on a common base with motor, shaft and bearings.

C. Wheel: Centrifugal, forward curved, die formed blades riveted to side and hub plates.

D. Steel shaft keyed to wheel, with grease lubricated ball bearings. Adjustable vee belt drive connected to an open dripproof motor mounted in a welded drive housing.

E. Manufacturer: Model/Series:
Buffalo Forge Co.
Peerless
Trane
Barry
Loren-Cook.

2.06 FAN: CENTRIFUGAL INLINE - SQUARE CONSTRUCTION

A. Factory assembled with all components mounted on a reinforced steel stand.

B. Casing: heavy gauge steel, square design, rigidly reinforced and supported, seams permanently sealed airtight. Flanged outlet connection. Provide access doors on two sides for easy access. All components shall be enamel primed and finish painted with enamel.

C. Wheel: all aluminum centrifugal backwardly included blades welded or riveted to the side and hub plates. Matching inlet cone.

D. Shaft: hot rolled steel, ground, keyed to the wheel.

E. Bearings

1. Self-aligning, grease lubricated, split pillow block type.

F. Drive: adjustable v-belt, factory set. Drives shall be rated for 165% of rated horsepower.

G. Open drip proof motor and drive enclosure.

H. Accessories:

1. Companion flanges
2. Motor cover
3. Inlet guards

4. Outlet guard
5. Inlet vane damper

I. Manufacturer: Loren-Cook. Model/Series: SQIB (or SQID)

Alternate manufacturers

Buffalo Forge co.
Peerless
Barry

2.07 FAN: CENTRIFUGAL - ROOF MOUNTED - UPBLAST - ALUMINUM

A. Roof exhaust blowers shall be of the belt drive, upblast, vertical discharge type. Housing shall consist of heavy gauge aluminum construction. All spun parts shall have a rolled bead for added rigidity and shall be specially spun so as to seal the pores of the aluminum providing greater resistance against oxidation and deterioration.

B. The fan wheel shall be all aluminum of the centrifugal blower type featuring backward inclined blades and a tapered inlet shroud. Wheels shall be statically and dynamically balanced. Inlet cone shall be aluminum and of centrifugal blower type. Motor and drives shall be enclosed in a weather tight compartment, separate from the exhaust airstream. Air for cooling the motor shall be supplied to the motor compartment by way of an air tube from an area free to contaminated exhaust fumes. Motors shall be of the heavy duty, permanently lubricated, sealed ball bearing type. Drives shall be sized for 165% of motor horsepower capabilities and of the cast iron type, keyed to the fan and motor shafts. Variable pitch drives shall be standard. Fan shaft shall be of steel construction, turned, ground and polished to precise tolerances in relationship to the hub and bearings. Drive belts shall be of oil-resistant, non-static, non-sparking type with life expectancy of over 24,000 hours. Bearings shall be flanged and of the permanently lubricated, permanently sealed, ball bearing type capable of over 200,000 hours bearing life. The entire drive assembly and wheel shall be removable, as a complete unit, from the support structure without disassembling the external fan housing. The complete drive assembly shall be mounted on rubber vibration isolation.

C. Direct drive units shall be of identical construction as belt drive units, except for drives, belts, and fan shaft bearings.

D.

Manufacturer:	Model/Series
Acme Engineering Co.	PU,PUH
Greenheck Fan Corp.	CU,CUBE
Loren Cook	ACRU
Penn Ventilator Co.	FUMEX

2.08 ROOF CURB: SOUND ATTENUATING

A. Provide a sound attenuating roof curb for all roof-mounted exhaust fans.

B.

Manufacturer:	Model/Series:
Acme Engineering Co.	SONE-MASTER
Greenheck Fan Corp.	AT

2.09 CV or VAV UNIT: LOW PRESSURE - HOT WATER REHEAT

A. Cabinet shall be constructed of zinc coated steel with minimum 1" internal insulation. Insulation shall meet standards of specification Section 233000.

B. Air volume damper shall be constructed of extruded aluminum components with nylon fitted bearings. Air leakage shall not exceed 2% at 1" W.G. inlet pressure.

C. Damper operator shall be factory mounted and compatible with space thermostats specified in specification Section 230923. Units shall be of the pressure independent type capable of operating with inlet pressures between 1.0 and 3.0 inches of water.

D. Unit shall be factory tested prior to shipment.

E. Heating Coil- Seamless copper tubes with brazed copper return bends and without internal turbulence inducers. Aluminum plate or helical fins. Red brass headers each with drains and vents.

F. Flanged minimum 16 gauge galvanized steel casings with mounting holes.

G. Mount and arrange components to permit expansion without strain on tubes, headers or casing and with all guides and supports necessary to assure proper alignment and drainage.

H. Support - All units shall be independently suspended from the building structure. Provide auxiliary steel for hanging where required. Resting the units on ceiling structure will not be permitted.

I. Manufacturer: Model/Series:
Enviro Tech
Titus
Trane.

2.10 FAN POWERED: HOT WATER REHEAT

A. Air volume damper, fan, and control shall be factory assembled.

B. Cabinet shall be constructed of zinc coated steel with full bottom access panel.

C. Cabinet internal surface shall be lined with 1" thick insulation. Insulation shall meet standards of Section 230700.

D. Air volume damper shall be located inside cabinet. Damper shall be constructed of extruded aluminum components. Pivots shall be nylon fitted. Air leakage shall not exceed 2% at 1" W.G. inlet pressure.

E. Fans shall be forward curved centrifugal type with direct drive permanent split capacitor type motor. Fan/motor assembly shall be isolated from the cabinet. Motor to be multi-speed.

F. Damper operator shall be factory mounted.

G. Unit shall be factory tested prior to shipment.

H. Heating Coil

I. Seamless copper tubes with brazed copper return bends and without internal turbulence inducers. Aluminum plate or helical fins. Red brass headers each with drains and vents.

J. Flanged minimum 16 gauge galvanized steel casings with mounting holes.

K. Mount and arrange components to permit expansion without strain on tubes, headers or casing and with all guides and supports necessary to assure proper alignment and drainage.

L. Provide 2" throwaway filter on fan inlet.

M. Manufacturer: Model/Series:
Titus
Trane
Anemostat

2.11 FAN COIL UNIT: CABINET - 2/4 PIPES

A. Vertical cabinet centrifugal type.

B. Cabinet: 18 gauge, nominal with 16 gauge front panels; channel formed edges around entire perimeter.

C. Chassis: Minimum 18 gauge galvanized steel, reinforced with flanged edges lined with 1/2" thick, 1 lb. density neoprene faced fiberglass. Galvanized steel drain pan with insulating liner.

D. Fan: Double inlet, double width, forward curved, galvanized steel wheel and scroll. Fan, motor and drain pan assembly shall be removable as a unit.

E. Coils:

1. Cooling/heating coil: 5/8" O.D. seamless copper tubes, with aluminum fins, mechanically bonded.

2. Test coils at the factory for maximum working pressures of up to 300 PSI.

F. Motors: Multispeed permanent split capacitor type directly connected to an extension of fan shaft. Maximum fan motor speed 1100 RPM. Provide integral thermal overload protection. Unit mounted fan speed switch. Provide special motors for all units scheduled with external static pressures of 0.10 inches or greater. Motors shall be capable of delivering scheduled CFM at static pressures indicated.

G. Filter: 1" disposable woven glass.

H. Accessories:

1. Two-pipe valve package with automatic summer/winter changeover (Trane H-37).

2. Four pipe valve package, including two way control valves for hot and chilled water, two stop valves for each service and an air vent on each service. Provide three way chilled water control valves where indicated on plans or in equipment schedules. Control valves shall be provided in conformance with Specification Section 230923.

3. Tamper proof panel

4. Unit sub-base.

5. Extended motor oiler lines.

I.	Manufacturer: Trane Carrier International	Model/Series: Unitrane

2.12 HUMIDIFIER: ELECTRONIC

A. Steam humidifier for distribution of humidity (steam vapor) into air handling system shall be of the self contained, electronically-controlled design.

1. Humidifier shall generate steam from ordinary tap water.

2. Humidifier(s) shall be all internal components contained in a steel cabinet with a key-locked access door to prevent unauthorized tampering.

3. Humidifier(s) shall be UL and CSA listed.

4. Humidifier shall have full modulating control to provide 0 to 100% capacity. It must also provide a gradual increase in amperage in order to avoid undesirable surges of current.

5. Humidifier capacity shall be fully field adjustable from 0 to 100%.

6. Humidifier shall have steam generator(s) that can be taken apart for inspection, cleaning or if needed, replacement parts.

7. Humidifier with three phase electrical power shall have field adjustable electrodes for efficient operation in different water conditions.

8. Humidifier shall incorporate an electronic timer to control the automatic water drain cycle (with one drain valve for each generator) which will evacuate minerals and particles left in suspension in the generator.

9. Automatic drain cycle will be field adjustable with a drain duration range of 2 to 128 seconds and a drain interval range of .25 to 16 hours.

10. The electronic circuit shall provide automatic protection from excessive electrode current and high water overflow.

11. The humidifier fill water line(s) shall have an air gap to prevent backflow (syphoning) of contaminated water into the water supply system.

12. Humidifier shall incorporate electrical terminals for installation of controlling stat, duct high-limit stat, interlock switch to fan motor.

13. Humidifier shall be supplied with stainless steel steam dispersion tube or grid which provide uniform steam distribution over the entire distribution area and shall be supplied at various lengths (through 6') to adequately span the widest dimension of the duct or unit.

14. Steam hose from generator to dispersion tube shall be of hard copper1-1/2" diameter to adequately convey steam to the tube and to drain any condensate back to the generator.

15. Humidifier shall be supplied with a solid state electronic sensor controller (humidistat) capable of fully modulating the steam flow.

16.

Manufacturer:	Model/Series:
Armstrong	600
Neptronic	SKM

2.13 UNIT HEATER: HOT WATER

A. Vertical or horizontal mounted with propeller fan direct connected to electric motor.

B. Coil: Copper tubes with aluminum fins mechanically bonded to the tubes.

C. Casing: Minimum 18 gauge steel with steel fan guard and horizontal deflection or outlet cone louvers. Finish in baked enamel.

D. Motor: Permanent split capacitor with built-in thermal overload protection.

E.

Manufacturer:	Model/Series:
Modine	HS
Carrier	
Trane.	

2.14 UNIT HEATER: ELECTRIC

A. Casing: 18 gauge die formed steel, phosphate coated and finished with two coats of baked enamel. Adjustable discharge louvers and protective inlet louvers. Furnish mounting brackets for ceiling mounting.

B. Heating elements of alloy resistance wire, fully enclosed in refractory, sheathed with copper coated steel; aluminum fins.

C. Motors: Totally enclosed, continuous duty, direct connected to an all aluminum fan. Maximum RPM - 1750.

D. Controls:

1. Automatic reset thermal overload protection.
2. Manual reset thermal overload
3. Low voltage thermostat for field mounting
4. Fin delay relay for field wiring
5. 24-volt control transformer
6. Prewired control kit
7. Factory installed heat recovery thermostat
8. Factory installed power disconnect switch

E. Manufacturer: Model/Series:
Chromolox MUH
Indeeco
Brasch.

2.15 CABINET UNIT HEATER: ELECTRIC

A. Basic unit shall be blow-through design with motor and fans in the air stream below electric heating bank. Fan discharge shall be baffled to insure even air flow through entire area of heating bank for even outlet temperature. Leveling bolts shall be provided on floor models. All non-recessed units shall be available with top or front discharge. Front or bottom inlet shall be available on non-recessed wall or ceiling models.

B. All solid panels of the front top and bottom panels shall be internally insulated to provide quiet operation and low surface temperature. Complete unit assembly shall be listed and approved by Underwriters' Laboratory, Inc.

C. Electric heating elements shall be single terminal end long life electric Fintubes with furnace brazed helical coiled fins for rapid heat transfer. Entire Fintube shall be finished in corrosion resistant finish. Fintubes shall be installed or removed individually and shall be center anchored to insure noiseless expansion and contraction.

D. Automatic reset snap-action type thermal protection shall be furnished through holding coil circuit of the control system relay(s) for protection in the event of overheating due to air blockage from any cause. Thermal protector shall be linear type to sense temperatures the entire length of heating elements to detect localized overheating from partial air blockages.

E. Motor and fan assembly shall be direct drive on all unit sizes using extended motor shaft on one fan unit double extended motor shafts on two fan unit and coupling with hollow steel shafts and end bearing on three, four, and five fan units. Two-speed permanent split capacitor type motors with built-in automatic reset motor overload protection shall be standard.

F. Fans shall be forwardly curved double inlet centrifugal type aluminum construction - and shall be modular in design.

G. Motor and fans shall be mounted on an extra heavy 14 gauge galvanized mounting plate forming an easily removable assembly. Motor leads shall be plug-in type for easy removal of the motor and fan assembly. Combination two-speed two-heat tamperproof switch shall be located with access through discharge air grille using Allen key for adjustment.

H. Integral thermostat control shall be standard on floor and wall mounted units and shall consist of factory built-in thermostat of sensitive bulb and capillary type fully enclosed and snap-acting to prevent radio or TV interference. The thermostat shall have a temperature adjustment range between 45°F and 95°F with tamper-resistant adjustment through the discharge grille by means of an Allen key. Either thermostat operates the single-phase holding coil circuit of the integrally mounted power control relay(s). This single phase relay holding coil circuit shall either be powered from the cabinet unit heater main power supply - or from a separate 120 or 24 volt single phase circuit.

I. An integral fan delay switch shall be standard to prevent discharge of cold air by delaying start-up of the fan motor until heating elements have warmed up. This same fan delay switch shall maintain motor operation after heating elements have been de-energized to dissipate any residual heat.

J. Floor wall and inverted mounted units shall be equipped as standard with a two speed/two heat selector switch which permits simultaneous tamper resistant "high-low" adjustment of fan speed and heat output by means of an Allen key through discharge grille. Ceiling mounted units shall be wired for high speed/high heat operation only.

K.

Manufacturer:	Model/Series:
Chromolox	CU
Indeeco	
Brasch.	

2.16 ADJUSTABLE V-BELT DRIVES

A. For all belt-driven equipment: A complete matched set to transmit the power to the driven equipment; not less than two belts per drive.

B. Sheaves: Adjustable plus or minus l0%. When motor is l5 HP or over, use, companion type sheaves.

C. Belts: Reinforced rubber or neoprene.

D. Service Rating: Not less than 200% of the maximum estimated load; greater if specified for particular apparatus.

E. Minimum efficiency: 95%.

F. Manufacturer:
Browning Mfg. Co.
T.B. Wood's Sons Co.

2.17 MACHINERY GUARDS

A. Guard all visible moving parts of machinery, including fan belt drives, by barriers constructed of properly supported and easily removed 1-1/4" x 1-1/4" x 1/8" galvanized angle iron frames and 3/4" No. 16 galvanized expanded metal mesh. Round and finish all guard edges.

B. Provide openings equal to twice the diameter of the shaft for the insertion of a tachometer in all machinery guards covering the ends of motor or equipment to allow adjustment of belt tension.

2.18 FILTER GAUGES

A. At each filter bank, provide a mounted 4-l/2" diameter dial gauge with brass valved connection tubing to brass static pressure sensing tips upstream and downstream of the filter bank.

B. Scale: Clean filter drop at mid scale
Graduated in 0.2" W.G. increments.

Manufacturer:	Model/Series:
F.W. Dwyer Mfg. Co.	Magnehelic Series 2000.

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in conformance with manufacturer's recommendations.

END OF SECTION 23 70 00

SECTION 260000

GENERAL PROVISIONS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this Division shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this Division as shown on the drawings, as specified herein, and/or as required by job conditions.

B. This Section 260000 governs general procedures, materials and workmanship as applicable to the electrical work specified in the other Division 01 sections. Refer to Division 01 sections for additional general requirements.

C. Perform the work in accordance with the requirements and provisions of applicable codes and laws.

D. Equipment, materials, and installation shall conform to applicable standards and requirements of the following organizations and documents:

ANSI	-	American National Standards Institute
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
CBM	-	Certified Ballast Manufacturers Association
CSA	-	Canadian Standards Association
ETL	-	ETL Testing Laboratories
FCC	-	Federal Communications Commission
FM	-	Factory Mutual
FS	-	Federal Specifications
ICEA	-	Insulated Cable Engineers Association
IEEE	-	Institute of Electrical and Electronic Engineers
IESNA	-	Illuminating Engineering Society of North America
NEC	-	National Electrical Code
NECA	-	National Electrical Contractors Association
NEMA	-	National Electrical Manufacturers Association
NESC	-	National Electric Safety Code
NETA	-	International Electrical Testing Association
NFPA	-	National Fire Protection Association
OSHA	-	Occupational Safety and Health Administration
UL	-	Underwriters Laboratories, Inc.

1.02 INTENT

A. It is the intention of the specifications and drawings to obtain finished work, clean, tested, and ready for operation.

B. Items and services not shown on drawings, but mentioned in specifications, or vice versa, or items and services necessary to render the work complete and ready for operation, even if not specified, shall be provided without additional cost.

C. Where conflicts occur between drawings and specifications, or within either document, the Contractor shall ask for and obtain a written clarification from the Architect prior to submitting his bid. Otherwise, the items or arrangements of superior quality, greater quantity or higher cost shall prevail and be included in the contract price.

1.03 WORK INCLUDED

A. The work under this Division shall include labor, material, equipment, services and administrative tasks required to complete and make operable the electrical work shown on the drawings and specified herein, and including, but not limited to, the following:

1. Preparation and submission of shop drawings, diagrams and illustrations.

2. Procuring necessary permits and approvals, and paying required fees and charges in connection with the work of this Division.

3. Coordinating with, and complying with requirements of, the local electric utility, telecommunications service provider, and other franchised utility and service companies as applicable to the scope of this work.

4. Record drawings.

5. Operating and maintenance instructions and manuals.

6. Identification labels, tags, charts and diagrams.

7. Final connections to electrical equipment and devices.

8. Cutting, drilling, and patching required for the work of this Division.

9. Excavation and backfill for underground electrical work.

10. Concrete housekeeping pads for floor-mounted electrical equipment.

11. Temporary light and power for construction purposes.

12. Testing and adjustment of systems and equipment furnished, installed, and/or connected under this Division.

1.04 REFERENCES

A. Section 01015 – Volatile Organic Compound (VOC) Limits for Adhesives, Sealants and Architectural Coatings

B. Section 01300 – Submittals

C. Section 01450 – LEED Requirements

D. Section 01515 – Construction IAQ Management

E. Section 01570 – Construction Waste Management

F. Section 019100 - Commissioning

1.05 APPROVALS

A. See General Conditions and Division 01 sections, in addition to the following requirements.

B. Submit for approval a list of manufacturers of equipment proposed for the work. Contractor's intent to use exact make specified does not relieve him of responsibility for submitting such a list.

C. Where any specific material, process or method of construction, or manufactured article is specified by name or by reference to catalog number of a manufacturer, or other standards, the intent is not to take precedence over the basic duty and performance specified, noted on drawings, or as required for intended results. The Contractor shall verify the duty specified with the specific characteristics of the equipment offered for approval.

D. If material or equipment is installed before it is approved, the Contractor shall be liable for its removal and replacement with no additional cost.

1.06 COORDINATION WITH OTHER TRADES

A. Prepare complete set of drawings showing necessary slab openings, cuts or holes in structural members and structural supports that require structural framing. Drawings shall clearly indicate sizes and location relative to established column lines. Drawings shall be made using the latest backgrounds available from the architect. Drawings shall be completed in sufficient time to allow for structural steel fabrication so as not to delay project schedule.

B. Shop drawing submissions shall demonstrate knowledge of the work of other trades, and shall show the locations of the work of other trades that affect the work of this contract.

1.07 COORDINATION DRAWINGS

A. Coordination drawings shall be completed as required in Division 01. Refer to Section 230000 for requirements and sequence of drawing development.

B. The electrical contractor shall add electrical work on the coordination drawings. Electrical work to be shown on the coordination drawings shall include, but not be limited to, panelboards, switchgear, transformers, motor control centers, variable frequency drives, and cable tray and conduit 2" and larger. Additional electrical work shall be shown on coordination drawings where close coordination is required. Access requirements shall be shown for equipment.

C. After other trades have included their work on the coordination drawings and noted conflicts, the trades shall meet to resolve conflicts and agree to acceptable solutions. Each trade shall sign coordination drawings. Items not shown on the coordination drawings are the responsibility of the omitting contractor and the contractor is subject to additional costs incurred by other trades.

D. The Architect and Engineer are not part of the coordination drawing process. The Engineer will provide assistance relative to acceptability of proposed installations to resolve conflicts.

E. Submit final signed coordination drawing to engineer. Only submit items that are different from previously approved shop drawings. Revisions shall be clearly indicated.

F. Any work fabricated or installed prior to sign off by the applicable trades shall be removed and re-installed in conformance with coordination drawings.

G. The overall coordination of the coordination process is the responsibility of the general contractor.

1.08 SUBMITTALS

A. Shop Drawing Schedule

1. The Contractor shall submit, within 30 days of the award of his contract, a schedule of proposed shop drawing submissions.

2. The schedule shall include the following information.

   a. Item to be submitted
   b. Date of submission
   c. Latest date for approval
   d. Manufacturers of the specified item.

3. Items not specifically listed as "approved equal" should be listed for consideration at this time.

B. See Division 260000 equipment sections for specific submittals required. Unless otherwise indicated, submittals are required for electrical devices, equipment, and systems including basic construction materials such as conduit, 600 volt building wire, and standard fittings and boxes.

C. Manufacturers' Data

1. If catalog cuts of standard manufactured items show different types, options, finishes, performance requirements, or other variations, those features that the Contractor proposes to furnish shall be clearly identified. If any variations from the catalog description are proposed or required, such variations must be clearly noted on the cut.

D. Shop Drawings

1. Shop drawings shall clearly indicate details, sectional views, arrangements, working and erection dimensions, kinds and quality of materials and their finishes, and other information necessary for proper checking and for fabrication and installation of the items, and shall include information required for making connections to other work.

2. Shop drawings shall be numbered consecutively, and drawings related to various units comprising a proposed assembly shall be submitted simultaneously so that such units may be checked both individually and as an assembly.

3. Shop drawings shall include a listing and labeling statement indicating products are listed and labeled by a certified testing laboratory or agency for all electrical materials, devices, appliances and equipment.

4. Contractor shall keep on the site, in good order, a complete up-to-date set of approved shop drawings. Shop drawings shall be made available for inspection by the Architect.

5. The approval of shop drawings will be for general conformance to drawings and specifications, and shall not be construed as permitting any departure from the contract requirements. If the shop drawings show any variations from contract requirements because of standard shop practices or other reasons, such variations shall be clearly identified on the drawings or specifically noted in the letter of transmittal, in order that, if acceptable, suitable action may be taken for proper adjustment in other work affected thereby. If the Contractor fails to so identify such variations, he will not be relieved of responsibility for executing the work in accordance with the contract, even though such shop drawings have been approved and the work installed. Approval shall not relieve the Contractor of responsibility for any error in details, dimensions, etc. that may exist on shop drawings, nor for the furnishing of materials or work required by the contract and not indicated on the shop drawings. Approval shall not be construed as approved departure from details or instructions previously furnished by the Architect.

6. No work for which shop drawings are required shall be executed until the Architect's approval is obtained.

E. Submittals will be reviewed for conformance with the contract drawings and specifications. The engineer's review stamp will be affixed to submittals. One of the following actions will be taken.

1. NO EXCEPTION - Submittal appears to comply with the contract drawings and specifications. Contractor is not relieved of responsibility to meet the requirements of the contract drawings and specifications due to errors, omissions, or conflicts with other equipment or trades.

2. EXCEPTIONS AS NOTED - Submittal appears to comply with the contract drawings and specifications except for the items noted by the engineer. Contractor is not relieved of responsibility to meet the requirements of the contract drawings and specifications due to errors, omissions, or conflicts with other equipment or trades.

3. REVISE AND RESUBMIT - In the opinion of the engineer the nature and/or quantity of exceptions is sufficient to require resubmission to demonstrate compliance. Submittals must be returned within 30 days for contingent acceptance to remain valid. Submittals will become rejected if not returned within 30 days.

4. REJECTED - Submittal does not comply with contract drawings and specifications.

1.09 RECORD DRAWINGS

A. Provide "Record Drawings" in accordance with Article 4 of the General Conditions Governing all Contracts, indicating in a neat and accurate manner a complete record of all revisions of the original design of the work. Include all changes and accurately record, on reproductions of the contract drawings or appropriate shop drawings and in digital format (on compact disk in Adobe Acrobat PDF and AutoCAD 2005 (minimum) ".dwg" and ".dxf" format), all deviations between the work shown on the contract documents and the work installed.

B. Submit for approval bound sets of the required drawings, manuals and operating instructions.

1.10 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Furnish manufacturers operating and maintenance instructions, parts lists and sources of supply for replacements in accordance with Division 01 - General Requirements.

B. Provide the following:

1. Complete sets of final and correct shop drawings, maintenance and replacement parts manuals, and operating instructions, for equipment supplied.

2. Bind each set within a common binder. Index and organize with a table of contents, to permit quick and convenient reference.

3. One day of instruction in operation and maintenance of equipment to Owner's maintenance force. Schedule a 2-week period, convenient to Owner, during which qualified personnel, including manufacturers' technicians and engineers will be available for Owner's instruction.

4. Master Operating Manual (submit in quadruplicate).

5. Manufacturer's mechanical and electrical equipment parts list of components of the systems listed on the equipment schedules, control diagrams and wiring diagrams of controllers.

6. List shall give system number, unit number, manufacturer's model number, and manufacturer's drawing numbers.

7. Step by step operating instructions for each system including preparation for starting, re-starting after power failure, or re-setting after overcurrent or short-circuit operation.

8. Maintenance instructions for each type of equipment.

9. Possible breakdowns and repairs for each type of equipment.

10. List of nearest local suppliers for equipment.

11. Manufacturer's literature describing each piece of equipment listed on the fixture, panel and equipment schedules and in the specifications including wiring diagrams and a copy of any applicable test reports.

12. As-installed control diagrams by the control manufacturer.

13. Recommended trouble shooting procedures in the event of foreseeable electrical system failure.

14. Complete "As-Installed" color coded wiring diagrams of systems and electrical motor controller connections.

15. Copies of the following test reports or study reports:

    a. Emergency power system.
    b. Computer grade isolation transformer.
    c. Lighting control system.
    d. Architectural dimming control system.
    e. Lightning protection system.
    f. Fire alarm system.
    g. Short circuit, arc flash and coordination study with final settings.
    h. Thermographic survey.

1.09 GUARANTEES AND SERVICES

A. Workmanship, installation materials, and equipment shall be guaranteed as specified in the General Conditions and Division 01.

B. Contractor shall leave entire system installed under this Contract in proper working order, and shall replace any work or material which develops defects within the guarantee period, including other work damaged as a result of such defects, without additional cost.

1.10 PERMITS AND CERTIFICATES

A. Prior to proceeding with any installation, the Contractor shall prepare and submit to the proper authorities for their approval working drawings required by them, and shall give necessary notices, obtain permits, and pay local, state and federal taxes, fees and other costs in connection with this work.

1.11 SHORT CIRCUIT, ARC FLASH AND OVERCURRENT PROTECTION COORDINATION STUDY

A. The equipment manufacturer shall perform and submit for review and approval (1) a short circuit study and (2) an overcurrent protection coordination study in accordance with IEEE "Red Book" Standard 141 for service and distribution equipment supplied, including (3) arc flash hazard calculations per IEEE 1584 and complying with NFPA 70E. The study shall include equipment specified in: Sections 263200 Emergency Power System, 263623 Automatic Transfer Switches, 210000 Fire Pump Transfer Switch, 262413 Switchboards, 262416 Panelboards, and 260943 Architectural Dimming Control Systems. Provide a computer generated format similar to SKM Systems Power Tools, EDSA Easy Power or approved equivalent. Study reports shall be reviewed and sealed by a professional engineer with the appropriate seal annotated on the title page. Reports shall include as minimum:

1. Short circuit summary.
2. Coordination summary.
3. Incident energies at each equipment, protective device, bus, and feeder.
4. Incident energies at defined working distances.
5. Arc-flash protection boundary.
6. Required protective flame resistant clothing class for arc flash areas.
7. Listing of assumptions.
8. One-line diagram(s) of complete system to include:
    a. Complete component identification to match project labels
    b. Transformer KVA and temperature rise
    c. CB/Fuse type, frame & trip
    d. Conductor quantity, size and length
    e. UL listed component AIC rating, including rating with upstream fuse, if applicable
    f. Calculated fault current at each node and labeled on the one-line diagram.
9. Short circuit computer program results.
10. Analysis of short circuit results including discussion of any problem areas.
11. Recommended solutions for any identified problem areas.
12. Branch & feeder composite computer generated time current curves for equipment and protective devices in system.
13. Analysis of coordination results including discussion of any problem areas.
14. Recommended settings of protective devices.
15. Appendices with time current curves in color, UL listings, manufacturer’s data, and supporting information used in study.

B. Manufacturer shall document that overcurrent protection devices will perform in accordance with their U.L. listings and ANSI/IEEE Standard 242.

C. The short circuit, arc flash and coordination study shall be included with the submittals for equipment included in the study and as listed above. Failure to include the study with the equipment submittals will cause the equipment submittals to be rejected.

D. The contractor shall be responsible for final field adjustment of ground fault, overload and short circuit settings of adjustable circuit breakers and replacement of fused devices in compliance with the short circuit and coordination study recommendations.

E. Provide labeling of equipment likely to require examination, adjustment, servicing or maintenance while energized to warn qualified persons of potential electric arc flash hazards in accordance with the results of the study and NFPA 70E.

1.12 LOSS CONTROL SERVICES THERMOGRAPHIC SURVEY REPORTS

A. Perform thermographic survey and inspection of electrical equipment within one (1) year of installation to include: utility service end boxes, pad mount transformers and medium voltage switches, medium voltage cable terminations and splices, switchboards, sub-distribution switchboards and panelboards, branch circuit panelboards, disconnect switches, transfer switches, fuses and circuit breakers, busway, transformers, cable splices, and equipment terminals as shown on the drawings. Perform thermographic survey of other equipment as indicated on the drawings. Thermographic surveys shall be performed during periods of maximum loading using imaging equipment capable of detecting a minimum temperature difference of 0.1ºC at 30ºC. Loose connections shall be tightened and re-surveyed to confirm adequate repair. Upon completion of survey, submit a report to include the following:

1. Complete description of equipment testing.
2. Any discrepancies found.
3. Temperature difference between the area of concern and the reference area.
4. Probable cause of temperature difference.
5. Areas inspected to include inaccessible and unused areas and equipment.
6. Load conditions at time of inspection.
7. Thermographs and photographs of the deficient area.
8. Corrective action recommendations.
9. Results submitted in formal bound report.

1.13 PRE-PURCHASE ITEM REQUIREMENTS

A. Coordinate with Construction Manager for installing the pre-purchased equipment as described in the bidding documents. The Contractor shall arrange for pickup, delivery to the site, and rigging of equipment to the final installation location shown on the drawings. The Contractor shall install and make fully functional the equipment and systems including installing factory-supplied items, controls, batteries, vibration isolation and other devices as outlined in the contract documents. Refer to other sections of this specification as applicable.

B. The Contractor shall assume the responsibility of providing the full warranty coverage of the pre-purchased equipment as outlined in the applicable specification sections.

PART 2 - PRODUCTS

2.01 MATERIALS, EQUIPMENT AND SYSTEMS

A. Materials and equipment and systems shall be new, bear manufacturer's name and trademark, and comply with applicable standards specified.

B. The UL label shall be borne on each piece of applicable material or equipment.

C. Equipment shall be provided with required hardware for proper installation, assembly, and operation.

D. The descriptions cover basic equipment and operation but not complete details of design and construction. The use of singular in descriptions does not limit the quantities of items to be furnished to provide the operation specified. Furnish equipment required to produce specified performance under installed conditions. Provide trim, enclosures and accessories required to make a complete installation.

E. Follow manufacturers' directions in delivery, storage, protection and installation of equipment and materials. Notify Architect promptly, in writing, of any conflict between requirements of the contract documents and manufacturers' directions, and obtain Architect's written instructions before proceeding with work. Bear any costs to correct deficiencies arising from failure to comply with the manufacturers' directions and instructions.

F. Deliver equipment and materials to the site and store in original containers, suitably sheltered from the elements. Store items subject to moisture damage in dry, heated spaces. Tightly cover and protect equipment against dirt, water, chemical, and mechanical injury, and against theft.

G. Equipment and materials of the same general type shall be of the same manufacturer, make and model throughout the work to provide uniform appearance, operation and maintenance.

2.02 EQUIPMENT DEVIATIONS

A. Contractor shall use the specified manufacturers. Any requests for substitutions, including 'or equals', must be submitted in writing ten (10) working days prior to the bid due date. Substitutions shall be justified on the basis of need, cost or both, as long as there is no identified reduction in quality and that design parameters are met. Acceptance or rejection of a substitution will be issued to bidders as an addendum. Substitutions will not be accepted after the Bid Date unless requested by the Architect. Note: Considering a manufacturer as an 'or equal' is considered a substitution.

B. Where the Contractor proposes to use an item of equipment other than that specified or detailed on the drawings, and which requires any additional utilities or redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical or electrical layouts, such redesign and new drawings required thereby, with approval of the Architect, shall be prepared by the Contractor without additional cost. Any changes in the project required to support alternates or substitutions shall be fully identified and submitted on the shop drawings for the substitute or alternate product. Such changes shall be reflected in the coordination drawings and shall be approved by the affected trades.

C. Where such approved deviation requires a different quantity or arrangement of equipment from that specified or indicated on the drawings, the Contractor shall provide any structural supports, controllers, motors, starters, wiring, conduit, and any other additional equipment required by the deviation, at no additional cost.

D. It is the intent of these specifications that wherever a manufacturer of a product or a catalog number is specified, and terms "or equal" or "or approved equal" are used, a substituted item must conform to the specified item. Consideration will not be given to claims that a substituted item meets performance requirements with lesser construction. Performance as indicated in schedules and in specifications shall be interpreted as minimum acceptable performance.

2.02 ACCESS DOORS IN WALLS AND CEILINGS

A. At each electrical component requiring access when located above ceiling or inside the wall not accessible by removal of grille, ceiling tile or from the air shafts, furnish access panels for installation by trades responsible for wall and ceiling construction as specified [under Division 08 – Access Doors and Panels. Size panels sufficiently to access products requiring inspection, maintenance and

adjustment, including but not limited to electrically operated valves, in-line controls, fire dampers, instruments and smoke or heat detectors.

1. Minimum size for panels: 16 by 16 inches.

2. Size panels located in masonry walls to match masonry coursing.

B. Locations: Locate panels in walls and non-accessible ceilings of closets, storage rooms and other non-public spaces to the greatest extent possible. When access panels are required in corridors and public spaces, locate panels as directed by Architect.

C. Panel type and materials: As specified under Division 08.

PART 3 - EXECUTION

3.01 SITE INVESTIGATION

A. Examine drawings, specifications, and site, and be responsible for the nature and location of work and the general and local conditions, particularly those bearing upon transportation, disposal, handling and storage of materials, availability of labor, electric power, roads, etc.

3.02 DRAWINGS

A. Drawings are diagrammatic and indicate the general arrangement of systems and work required. Do not scale the drawings. Consult the Mechanical and Architectural drawings and details for exact locations of equipment.

B. Drawings shall be used in layout of work. Check reference drawings to verify spaces in which work will be installed, and maintain maximum headroom and space conditions. Where headroom, working clearance or space conditions appear inadequate, Architect shall be notified before proceeding with installation.

C. If directed by the Architect, make minor modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.

3.03 COORDINATION WITH OTHER TRADES

A. Closely schedule the work so that the work will be installed at the proper time and without delaying the project's completion.

B. Where the work of this Division is to be installed in close proximity to the work of other trades, or where there is evidence that the work will interfere with the work of other trades, assist in working out space conditions to make a satisfactory

arrangement. If the work is installed before such coordination with other trades, make necessary changes in the work as directed by the Architect to correct any conflicts or interferences, without additional cost to the Owner.

3.04 COORDINATION AND LAYOUT

A. Study drawings and specifications to ensure completeness of work required. Include supplementary items normal to manufacturers' requirements or standard accepted trade practices as necessary to complete the work, even if not explicitly shown or specified.

B. Verify measurements and conditions in field before starting work.

C. Examine materials, surfaces, and structures to which work is to be applied and notify the Architect, in writing, of any conditions that are detrimental to proper and expeditious installation of work. Starting of work shall be construed as acceptance of conditions.

D. Confer with other trades to install work to avoid interference with other trades. The necessary adjustments to conform to structural conditions and work of other trades, particularly ductwork and piping layouts, are included under this section. Assist other trades in the preparation of coordinated layout drawings.

3.05 CONNECTIONS TO EQUIPMENT FURNISHED UNDER OTHER DIVISIONS OR BY OWNER

A. Provide electrical connections to equipment and fixtures requiring such connections which are supplied by Owner or under other Divisions.

B. Provide conduit, wire, lugs, fittings, accessories, and trim for final connection of each item of equipment as required for complete assembly and specified operation.

3.06 WORKMANSHIP

A. Perform work in practical, neat, and workmanlike manner, with electricians skilled in the work they are performing, and using the best generally recognized trade practices.

B. No work shall be covered or hidden from view until it has been inspected and approved by the required Building Department personnel and the Architect.

C. Workmanship or materials not meeting with requirements of the specifications or drawings, or the satisfaction of the Architect, shall be rejected and shall be immediately replaced in an acceptable manner without additional cost.

3.07 TESTS

A. Testing on incoming services shall be in accordance with Local Power Company requirements. Tests shall be performed by an approved independent testing Company in the presence of the Architect, Owner, and the local Utility.

B. Notify Architect, in writing, at least one week prior to tests, of the proposed testing timetables. Perform tests with the approval of and in the presence of the Architect or his representative.

C. Provide temporary connections, necessary testing equipment, labor and materials, required for the testing of the systems and equipment. Systems shall be prepared for testing and protected from damage. Measuring instruments shall be properly calibrated. The cost of tests shall be included in the contract price.

D. Verify and correct as necessary the following: voltages, tap settings, trip settings, and phasing on equipment and devices furnished or installed. Secondary voltages shall be tested at the bus in the main switchboard, at panelboards, and at such other locations on the distribution systems as necessary. Secondary voltages shall be tested under no-load and full-load conditions.

E. Set GFI trip settings as required by the short circuit and protective device coordination study or as directed by the Architect. Initially, prior to final trip settings, set up as follows upon installation:

1. Main GFI (no downstream GFI CB): Time at minimum and maximum amp.
2. Main GFI (with downstream GFI CB): Time at maximum amp.
3. Downstream GFI: Time at twenty five percent of maximum and amp at twenty five percent of maximum.

F. Electronic solid state trip units shall be set by a manufacturer's trained technician as follows:

1. Circuit breakers with solid state trip units shall be initially pre-set to the equivalent LT, LTD, ST, STD setting of the thermal magnetic version of the same ampere rated circuit breaker.
2. Instantaneous setting shall be not less than 4X.

G. The ground grid systems shall be tested using the three terminal fall in potential method. A minimum of eight test points for each ground grid system shall be submitted for review by the Architect. The test points shall be made along a straight line from the grid system to the reference terminal. The distance between the grid system and the reference terminal shall be consistent with normal practices for ground testing. Grounding tests shall be performed during the dry

season. Tests shall be performed before loaming and seeding or paving work has been performed.

H. Provide a written report on testing and device settings. Include a copy in the Operation and Maintenance Manual.

I. Adjust occupancy sensors for proper operation including time delay, field of view (masking), typed sensing and parallel operation.

J. Test wiring, outlets, lighting fixtures, switches, controllers, starters, motors, etc., wired under this Division. Leave free from grounds, crosses, shorts, opens, etc., and leave materials and apparatus in proper and satisfactory working condition. Perform additional tests as listed in the other Division 260000 specification sections.

K. Lighting fixtures shall be tested with specified lamps in place for not less than ten hours; the fixtures may be checked in sections.

L. Test for proper operation of emergency lighting equipment under simulated emergency conditions.

M. Test distribution equipment, motors, and three phase receptacles for proper phase connections and phase rotation.

N. Test service entrance, switchboards, panelboards, feeders, branch circuits and receptacles for proper neutral and grounding connections.

O. Prior to energizing, test insulation resistance of conductors and distribution equipment with a 500VDC megger, both phase-to-phase and phase-to-ground. Do not energize any circuits with a reading of less than one megohm (1 million ohms) for #6 AWG wire and smaller or 250,000 ohms for #4 AWG wire or larger, between conductors and between conductor and the grounding conductor. Circuits under megger insulation test shall be connected to respective final terminals but with switches and breakers in the "OFF" position.

P. After fixtures, devices, and equipment are installed and connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and the grounded enclosure and test insulation resistance. If this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from the neutral bar. He shall then test each branch circuit separately to the panel until the low readings are found. The contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.

Q. Prior to energizing, test for continuity and identification of each conductor. Identify both ends of each conductor.

R. Perform additional tests required by Owner, Architect or any other authorities having jurisdiction.

S. Correct or replace any circuit, material or equipment that is found to be defective by these tests. Correct defects, whether due to faulty workmanship or material furnished, in a manner acceptable to Architect without additional cost.

3.08 IDENTIFICATION

A. Equipment

1. Identify each item and the system or area it serves. Provide an engraved lamicoid nameplate in a visible location on each switchboard, panelboard, disconnect, switch, motor control center, inverter, automatic transfer switch, annunciator and similar equipment. Provide stencils on major equipment.

2. Switchboard devices, panels, cabinets, junction boxes, switches, controllers, motors, etc., shall be identified as to systems, voltage, phases, horsepower, fuse size, circuit breaker size, heater size, magnetic size, and feed location on their exteriors.

3. Provide printed labels for all equipment in the system from the project short circuit, coordination & arc flash study file. Assume three (3) labels per equipment/bus in your estimate using 4” x 6” labels or one (1) 6” x 8” label per equipment bus. The labels shall be UV resistant vinyl labels (white with orange warning strip and black letters) conforming to ANSI-Z535. The labels shall be printable directly from the power system software utilized for the study with a Duralabel, Brady PowerMark or GlobalMark printer.

B. Wiring

1. Provide vinyl cloth self-adhering labels for feeders and branch circuits in pull boxes, junction boxes, cabinets, and outlets to identify each feeder and circuit. Manufacturer: Panduit Pan-Code, Brady or approved equal.

2. Cables and branch wiring shall be identified showing phasing, system designations, and items served. Identity is required in switchboards, panels, junction boxes, switches, controllers, cabinets, etc.

C. Provide complete, accurate, typewritten panelboard and switchboard directories mounted securely to panelboard doors and switchboard faces. Directories to include for each circuit: room number or area served and load description.

D. Label receptacle cover plates to indicate source panelboard and branch circuit breaker number at bottom of cover plate. Provide typewritten self-adhering labels with black text and clear background, Brady or approved equal.

E. Label covers of pullboxes and junction boxes for systems operating over 600 volts with readily visible lettering at least ½-inch high warning "DANGER HIGH VOLTAGE KEEP OUT." Provide warning signs to unauthorized personnel at doors to buildings, rooms or enclosures containing equipment operating over 600 volts.

F. Label covers of pullboxes and junction boxes with readily visible lettering at least 1/4-inch high system, source panel, circuit number and voltage. Provide typewritten self-adhering labels with black text and clear background, Brady or approved equal.

G. Install a permanently affixed sign at the service entrance equipment indicating the type and location of the on-site emergency power source. Install a sign on the main grounding box identifying all emergency and normal sources connected at that location.

H. Provide a reduced size "as-built" single line diagrams, framed under glass, and mounted in a conspicuous place adjacent to the main switchboard.

3.09 CUTTING, ALTERING AND PATCHING

A. Provide cutting, chasing, drilling, altering and rough patching required for the work of this division.

1. Including the restoring of existing work cut for or damaged by installation of new work, and where present work is removed.

2. Materials and workmanship required in connection with cutting, altering and rough patching shall match the existing work in every respect.

B. Do shoring, bracing, cutting, patching, piecing out, filling in, repairing and refinishing of present work as made necessary by the alteration and the installation of new work.

C. Holes and openings occurring in the existing floors after equipment, partitions, floors, steel work, conduits are removed or installed shall be closed up with materials similar to the adjacent work.

D. The size and location of items requiring an opening, chase or other provisions to receive it shall be given by the trade requiring same in ample time to avoid undue cutting of any new work to be installed. These provisions shall not relieve the Contractor from keeping informed as to the required opening, chases, etc., nor from responsibility for the correctness thereof, nor for cutting and repairing after the new work is in place.

E. Include cutting, repairing and patching in connection with the work that may be required to make the several parts come together properly and fit it to receive or be received by the work of other trades, as shown on the drawings and/or specified, or reasonably implied by the drawings and specifications.

F. Repairing, patching, piecing-out, filling-in, restoring and refinishing shall be neatly done by mechanics skilled in their trade to leave same in condition satisfactory to the Owner.

G. Materials and their methods of application for patching shall comply with applicable requirements of the specifications.

1. Materials and workmanship not covered by the specifications and items of work exposed to view adjoining existing work to remain shall conform to similar materials and workmanship existing in or adjacent to the spaces to be altered.

H. Cutting, repairing and patching shall include items shown on the drawings, specified in the specifications or required by the installation of new work or the removal of existing work.

I. Remove partitions, walls, suspended ceilings, etc., as necessary to perform the required alterations or new construction work. Avoid damage to construction and finishes that are to remain.

J. Protect and be responsible for the existing building, facilities and improvements. Any disturbance or damage to the work, the existing building, and improvements, or any impairments of facilities resulting from the construction operations, shall be promptly rectified, with the disturbed, damaged, or impaired work, restored, repaired or replaced at no extra cost.

K. Alterations which are not indicated on the drawings nor specified herein but necessary to make good existing work disturbed by reason of the work shall be restored to a condition satisfactory to the Owner.

L. Holes in masonry floors and walls are to be core drilled. Scan existing slabs and walls for concealed locations of equipment to include: conduits, piping, rebar and structural elements prior to being core drilled. Prior to core drilling, notify the

building occupants of the potential for an unscheduled power outage. The Project Manager shall inspect core holes before installing conduits, sleeves, or poke-through devices. Conduits damaged during core drilling shall be restored immediately at the Contractor's expense.

M. Disturbed concrete and /or cement floor areas shall be patched with approved type latex mortar. When cement mortar is used for patching, the surfaces shall be depressed a minimum depth of 1".

N. Reinstall weather protection work in waterproof manner.

O. Openings in roofs shall be kept properly plugged and caulked, except when being worked on, to preclude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed.

P. Temporary openings cut in walls, floors or ceilings for conduit shall be closed off with non-combustible material except when mechanics are actually working at the particular opening.

3.10 SLEEVES AND SEALING

A. Install sleeves of Schedule 40 galvanized steel pipe for conduits and cables penetrating above-grade floor slabs, and any concrete or masonry walls. Sleeves through walls shall terminate flush with wall surface on each side. Sleeves through floors shall terminate 2 inches above finished floor. Neatly and completely grout sleeves in place.

B. Sleeves shall be adequately sized for the conduits and cables to be installed, with sufficient free space to install sealing caulk or putty.

C. Sleeved conduits through slab-on-grade floors, below-grade foundation walls, shafts, [tanks, fountains,] and the like shall be provided with sealing bushings to seal against fluid and gas pressure and installed in accordance with UL and manufacturer's instructions.

D. Where penetrating floor slabs and fire-rated partitions, pack the annular space between the sleeves and the conduits and cables with reusable fire-retardant modules, putty, sealant, or caulk. The sealant material shall be intumescent, asbestos free, and installed in accordance with UL and manufacturer's instructions. Sealant materials shall be easily removed and replaced for addition or deletion of cables.

1. Penetrations with annular space greater than 1/2" shall be provided with approved backing material.

2. Fire-retardant sealer and system shall be UL listed for the application and meet ASTM E-84, ASTM E-814, and UL-1479 requirements. Use Hilti Firestop Systems, CSD Sealing Systems, Nelson "FSP", Carborundum Co. "Fyre Putty", 3M "CP-25", IPC "Flamesafe", ROX System or approved equal.

E. Where cable tray penetrates floor slabs, ceilings and rated partitions, the cable tray shall stop at the floor, ceiling or wall. Provide a fire-rated pathway through floor, wall or ceiling of equivalent size to the cable tray dimensions. The cable tray shall then be continued on the opposite side of the floor, ceiling or wall. The cable tray shall be grounded and bonded for electrical continuity. The contractor shall maintain the floor, ceiling and wall rating.

1. Fire-rated pathway products: STI EZ-Path Series 22, 33 and 44 or approved equal by Wiremold or Hilti.

F. Contractor shall photographically document that proper sealing bushings, fire stopping, sleeving and pathway products have been provided before locations are hidden from view. Refer to Section 260500 for additional information.

3.11 PLENUM APPLICATION

A. Space above the hung ceilings shall not be used as a return air plenum (air transfer), except where specifically indicated on the mechanical drawings and/or other drawings. Material in spaces so noted shall be suitable for use in plenum application. In spaces so noted, no combustible materials shall be used. Wiring shall be in conduit, or shall be listed for the use, and shall comply with the requirements of NFPA 70, Section 300-22, as well as other applicable codes. Materials used in plenum spaces shall have flame spread/smoke developed ratings as required by code and/or authorities having jurisdiction.

3.12 TEMPORARY LIGHT AND POWER

A. Contractor shall furnish, install and maintain a temporary light and power system to provide the buildings, field offices, and project site with temporary light to provide safe working conditions throughout, interior and exterior, and to supply construction power as required on the job.

B. The system shall be furnished, installed, and operating at the earliest possible date.

C. Work for the system shall be in accordance with NEC Article 590, the requirements of the Utility Company, and as approved by the Owner and authorities having jurisdiction.

D. The work shall include generally, but not be limited to, the following:

1. Make arrangements with the utility company or the Owner to furnish and install the temporary light and power service.

2. Review and coordinate the electrical needs of other trades on a continuing basis, until permanent power and light is available and the temporary system is removed and no longer needed.

3. Furnish, install, and maintain required temporary system equipment, devices, and wiring. Remove when no longer needed, or at the direction of the Owner. Modify, add, or relocate equipment, devices, and wiring as required to suit job conditions.

END OF SECTION 26 00 00

SECTION 26 05 00

BASIC MATERIALS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions.

B. See other Division 26 sections for requirements of specific electrical equipment and systems not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation are based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' catalog data for the following basic materials:

1. Surface raceways and fittings.
2. Wireway, trough, and fittings.
3. Flexible cable tray and fittings.
4. Cable hangers.
5. Wire and Cables.
6. Wiring devices and wallplates.
7. Floor boxes and fittings.

8. Disconnect switches and fuses.
9. Circuit breakers.
10. Underground line marker tape.
11. Surge Protection Devices (SPD).
12. Submetering.
13. Switch bypasses devices.

B. Submit scaled and dimensioned shop drawings for the following:

1. Custom-fabricated pull, junction boxes, and terminal boxes.
2. Exposed raceway installations in architecturally finished spaces.

C. Submit samples of the following:

1. Wiring device wall plates.
2. Wiring devices.

PART 2 - PRODUCTS

2.01 WIRING & RACEWAY SCHEDULE

A. Except where specialty wiring methods are called for, use wiring methods selected in accordance with the following list. Use threaded rigid steel conduit with wire installed as the wiring method for purposes and in locations not covered by the following list and where the listed wiring methods are excluded.

RACEWAY & WIRE	APPLICATION
Threaded Rigid Steel Conduit (RSC)	1. Fire pump, jockey pump; and associated control circuits. 2. Exposed outdoors, roofs, stub-ups, or penetrations through concrete slabs or equipment pads. 3. Circuits above 600 volts.

Electrical Metallic Conduit (EMT)	1. Interior, dry locations for: switchboard and panelboard feeders. 2. Branch feeders, lighting and appliance circuitry. 3. Homeruns to overcurrent protection device. 4. Fire alarm (Section 283100). 5. Telecommunications (Division 27) IT consultant specifications. 6. Sound & video (Division 27) AV consultant specifications. 7. Security (Division 28) Security consultant /vendor specifications.
Rigid Non-metallic Conduit (RNC)	1. Below grade, below slab – Schedule 40 2. Outdoors where exposed to physical damage and in corrosive locations where shown on drawings – Schedule 80. 3. Encased in concrete, concrete ductbanks - Schedule 40.
Flexible Metal Conduit (FMC)	1. Final connections minimum 18 inches and less than six (6) feet only for lighting and appliance branch circuitry in accessible voids of suspended ceilings 2. Final connections minimum 18 inches and less than three (3) feet to motors in mechanical rooms 3. Other interior dry locations, or where located in plenums or other spaces used for environmental air. 4. Provide grounding conductor.
Liquidtight Flexible Metal Conduit(LFMC)	1. Final connections minimum 18 inches and less than three (3) feet only for lighting and appliance and motor branch circuitry in exposed wet or damp locations. 2. Do not use in plenums or other spaces used for environmental air. 3. Provide grounding conductor.
Metal Clad Cable (MC)	1. Not allowed.
Optical Fiber/Communications Cable Raceway	1. Inner duct for communications applications in conduit or ductbank.

Surface Metal Raceway	1. Exposed work in finished areas only where specifically indicated on drawings or approved by the Architect. 2. Exclude in concealed locations.
Flexible Cable Tray	1. Low voltage, voice, data and video systems in exposed locations and above accessible ceilings.

B. Minimum raceway size: 3/4-inch. Exception: Provide minimum 1-inch below grade or below slab on grade locations and unless otherwise noted.

C. Provide equipment ground conductor per 3.04.

2.02 RACEWAYS

A. Provide raceways of the types and sizes indicated and specified, or as required to comply with codes and job conditions where not so indicated or specified.

B. Metallic Conduit, Tubing, and Fittings

1. Rigid steel conduit shall be hot-dip galvanized, conforming to ANSI C80.1, UL 6, and NEC Article 344. Fittings and couplings shall be threaded. For outdoor locations provide raintight conduit hubs with insulated throat and bonding screw equal to O.Z. Gedney Type CHM-T. Die-cast fittings are not acceptable.

2. Electrical metallic tubing (EMT) shall be galvanized steel, conforming to ANSI C80.3, UL 797, and NEC Article 358. Provide with galvanized steel compression type fittings, couplings, and connectors for sizes less than 1-1/2 inch. Provide with galvanized steel double set screw type fittings, couplings, and connectors for sizes 1-1/2 inch and larger. Die-cast fittings are not acceptable.

3. Liquidtight flexible metal conduit shall have an interlocked flexible galvanized steel core with a permanently bonded polyvinylchloride (PVC) jacket, conforming to UL 360 and NEC Article 352. Die-cast fittings are not acceptable.

C. Flexible metal conduit shall be interlocked flexible galvanized steel conforming to UL 1 and NEC Article 348. Provide malleable iron fittings, UL 514B. Die-cast fittings are not acceptable.

D. Connectors for metal conduit shall be insulated throat type. Provide galvanized steel grounding bushings or locknuts at metallic raceway connections to sheet steel boxes and enclosures. Die-cast fittings are not acceptable.

E. Connectors for metal conduits which contain BOTH normal ground AND isolated-ground conductors, where the conduit is NOT being used as the equipment grounding conductor, shall be phenolic insulating types. O-Z Gedney Type ICC or approved equal. (For conduits containing only a normal ground conductor or only an isolated ground conductor, where the conduit is also used as the equipment grounding conductor, provide galvanized couplings and connectors as specified above.) Die-cast fittings are not acceptable.

F. Expansion fittings for metal conduit shall be as follows:

1. Rigid metal conduit in air: Provide 4-inches conduit expansion and contraction allowance; O.Z. Gedney Type AX or approved equal.

2. Rigid metal conduit in concrete or wet locations: O.Z. Gedney Type DX or approved equal.

3. EMT conduit in air: Provide 4-inches conduit expansion and contraction allowance; O.Z. Gedney Type TX or approved equal.

G. Non-Metallic Conduit and Fittings

1. Schedule 40 and Schedule 80 rigid non-metallic conduit shall be polyvinyl chloride (PVC), rated 90 degrees C., conforming to NEMA TC-2, UL 651, and NEC Article 352. Provide with matching fittings conforming to NEMA TC-3 and UL 514.

2. Expansion fittings for PVC conduit shall be as follows:

a. PVC conduit in concrete or wet locations: O.Z. Gedney Type EX or approved equal.

H. Optical Fiber/Communications Cable raceway and fittings in reel lengths manufactured of high density polyethylene (HDPE). Comply with UL 2024; flexible type, listed for plenum, riser or general purpose. Include factory installed polyester tape. Fittings, cement and accessories shall be from one manufacturer; Lamson & Sessions Carlon Corrugated HDPE or approved equal.

I. Surface Metal Raceway

1. Provide two-piece surface metal raceway of the types, sizes, and configurations indicated, complete with fittings, boxes, devices, covers, plates, mounting straps, etc. as required for a finished installation, in conformance to UL 5 and NEC Article 386.

2. Provide fittings for flush feed-in unless otherwise indicated or required.

3. For multi-service power/telecommunications surface raceways, provide continuous metal divider between compartments.

4. Large surface metal raceway and components shall be Wiremold Co., DS4000 Designer Series, 2"D x 5-1/2"H, [aluminum with satin anodized finish]galvanized steel with finish color per Architect, unless otherwise shown on drawings. [Large surface metal raceway and components shall be Wiremold Co., G4000, 1-3/4"D x 4-3/4"H, unless otherwise shown on drawings, or approved equal as manufactured by Mono-Systems, Inc., ivory color.]

5. Provide metal raceways with factory installed conductors and attachment plug receptacles. Receptacles shall be specification grade, 15 ampere, 125 volt mounted (18) inches on center. Do not attempt field installation of additional conductors except where product is so marked.

6. Provide multi-outlet assemblies suitable for installation in accordance with Article 353 of the NEC. Fittings shall be manufactured by the multi-outlet assemblies manufacturer under UL5. Provide Wiremold G2000 raceway, 2000 Plugmold and matching fittings in ivory color or approved equivalent by Mono-Systems, Inc. Where indicated to serve audio systems, provide Wiremold 2000 IG series and label "Audio Only – Technical Power."

J. Wireways and Troughs

1. Provide factory-fabricated sheet metal wireways and troughs of the types, sizes, and configurations indicated, or as required to suit job conditions, complete with fittings, connectors, end plates, hangers, etc. as required for a finished installation. Products shall be galvanized steel with ANSI 61 gray acrylic electrocoat finish. Fittings and components shall conform to UL 870 and NEC Article 376.

2. Wireways, troughs, and components shall be as manufactured by Square D, Hoffman Engineering Co., Wiegmann & Co., or approved equal.

K. Flexible Cable Tray

1. Provide flexible cable trays for low voltage, voice, data, and video wiring, of the sizes and configurations indicated, complete with fittings, connectors, hangers, etc. as required for a finished installation to Category 6A UTP standards.

2. Unless otherwise indicated, flexible cable trays shall be welded wire mesh permitting continuous ventilation of cables. Provide straight sections in

118-inch lengths suitable for field bending and fitting to cable pathway contours. Minimum tray width shall be 12-inch by 6-inch depth unless otherwise indicated.

3. Finish: Wire to be welded, bend and surface treated after manufacture. Surface finish to be hot dip galvanizing in molten zinc bath providing an average coating thickness of 2.4 mils to 3.2 mils, where used outdoors; electro-plated zinc galvanizing where used indoors.

4. Fittings: Cable management fittings to be field manufactured from straight sections through the use of hardware and instructions supplied by the manufacturer. Fasteners and hardware shall be stainless steel.

5. Installation: Cable management system to be installed using splice connectors and support components as supplied by the manufacturer.

6. Where cable tray penetrates floor slabs, ceilings and rated partitions, the cable tray shall stop at the floor, ceiling or wall. Provide a fire-rated pathway through floor, wall or ceiling of equivalent size to the cable tray dimensions. The cable tray shall then be continued on the opposite side of the floor, ceiling or wall. The cable tray shall be grounded and bonded for electrical continuity. The contractor shall maintain the floor, ceiling and wall rating.

   a. Fire-rated pathway products: STI EZ-Path Series 22, 33 and 44 or approved equal by Wiremold or Hilti.

7. Loading: Flexible cable trays shall be designed to support a load of 100lbs./ft. across a 12” span with a maximum deflection of 1.5 inches. In addition, the tray shall be capable of supporting a 200lb. concentrated load at mid-span without damage or permanent deformation.

8. Flexible cable tray shall be sized for 30% fill based on the installed cable load.

9. Flexible cable trays shall be as manufactured by B-Line, G.S. Metals Flextray, Cablofil Inc. EZ Tray, Cope Cat-Tray or approved equal.

L. Cable Hangers

1. Provide non-compressing, non-continuous cable supports for low voltage, voice, data, and video wiring and fiber optic cable, of the sizes and configurations indicated, complete with fasteners, anchors, cable pulling protection and as required for a finished installation to Category 6A UTP standards.

2. Finish: A653 G60-Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-coated (Galvannealed) by the Hot-Dip process.

3. Manufacturers: Caddy CableCat, Panduit J-Pro or approved equal.

4. Installation: Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ EIA/TIA Standards 568 & 569, NFPA 70 (National Electrical Code), applicable local codes, and to the manufacturer's installation instructions.

   a. Install cables using techniques, practices, and methods that are consistent with Category 6A UTP or higher requirements and that supports Category 6A UTP or higher performance of completed and linked signal paths, end to end.

   b. Install cables without damaging conductors, shield, or jacket.

   c. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

   d. Pull cables without exceeding cable manufacturer's recommended pulling tensions. Use pulling means that will not damage media.

   e. Do not exceed load ratings specified by manufacturer.

   f. Adjustable non-continuous support sling shall have a static load capacity of 100 lbs.

   g. Cable hangers shall be sized for 30% fill based on the installed cable load.

2.03 600 VOLT WIRE AND CABLE

A. Wire and cable for secondary power and lighting circuits and for NEC Class 1 control circuits shall be fabricated of annealed 98% conductivity copper conductors with 600 volt, 90^{o}C-rated, thermoplastic or cross-linked polymer insulation, manufactured in strict accordance with applicable requirements of UL, NEMA, ICEA and ASTM.

B. Copper conductors No. 10, 12, and 14 AWG shall be solid or concentric stranded Type THHN/THWN-2; No. 8 AWG through No. 1 AWG shall be concentric stranded Type THHN/THWN-2; No. 1/0 AWG and larger shall be concentric stranded Type XHHW-2.

C. Bare grounding conductors: See paragraph 2.08 Grounding Materials.

2.04 TERMINATIONS

A. Terminations, splices and taps under 600 volts:

1. Copper conductors No. 10 and smaller: Provide with copper compression type or twist-on spring-loaded connectors and nylon insulating covering. Connectors for outdoor conductors shall be suitable for direct burial installation.

2. Copper conductors No. 8 and larger: Provide hydraulic copper compression type using manufacturer's recommended tooling, Burndy or approved equal; or mechanical bolted pressure type, Ilsco ClearTap or Cytolok spring compression terminator or approved equal. Exception: Wiring terminations rated 100,000 amperes short circuit current and greater shall be provided with compression type lugs.

3. Cable lugs and connectors: Provide compression type of tin-plated copper. Provide to match cable, pre-filled with antioxidant compound, UL486B listed, with marking indicating size and type. Where oversized feeders are installed to reduce voltage drop and the equipment terminations are not sufficient to accept the larger feeders, provide the proper equipment terminations or provide Burndy Type YE-series or approved equivalent compression adapters.

4. Lug connections to bus bars: Provide with tin plated lugs and Belleville compression washers. Use anti-seize compound on threads. Provide 2-hole type for ground lugs.

2.05 ELECTRICAL BOXES

A. Provide outlet, junction, pull, and floor boxes, complete with associated fittings and accessories, as indicated and specified, as required by codes, to suit job conditions, and compatible with the associated wiring methods and devices.

B. Interior Outlet Boxes

1. Provide galvanized pressed steel boxes of appropriate size and type. Provide each with appropriate plaster ring to suite wall construction.

2. Unless otherwise indicated, or required by job conditions, provide boxes as follows:

a. Flush wall power outlets in hollow partitions - 4" square, 1-1/2" deep, with 1- or 2-gang device cover; provide gang boxes for 3 or more adjacent outlets.

b. Flush wall power outlets in masonry walls - 3-1/2" deep masonry boxes, with number of gangs as required.

c. Recessed switches - 3" x 2" x 3-1/2" deep, gangable.

d. Surface mounted power devices - 4" square, 1-1/2" deep, with rounded corners and appropriate raised cover.

e. Flush or surface telecom outlets - 4" square, 2-1/8" deep, where 1" knockouts are required; 4-11/16" square, 2-1/8" deep, where 1-1/4" knockouts are required.

f. Refer to “Floor Box” product descriptions for specific floor box dimensions.

C. Exterior or Wet Area Outlet Boxes

1. Provide corrosion-resistant cast metal raintight boxes with threaded conduit entrance fittings, Myers Scru-Tite hubs or approved equal.

2. Covers shall be gasketed PVC, with spring-loaded weathertight-while-in-use covers as appropriate for the application.

D. In-ground Cast Boxes

1. Provide vehicular traffic bearing cast polymer resin concrete or non-traffic bearing cast fiberglass underground junction and pull boxes with closed [open] bottoms for flush mounting as shown on drawings.

2. Cover shall be non-skid with neoprene gasket and stainless steel cover screws. Cover legend: ELECTRIC, TELEPHONE, CATV and as shown on drawings.

3. Manufacturers: Cast iron or aluminum - O-Z Gedney, Crouse-Hinds; Polymer concrete – Quazite, Synertech or CDR Systems Corporation; Cast fiberglass – PenCell, CDR Systems Corporation; or approved equivalents.

E. Pull and Junction Boxes

1. Provide galvanized and baked enamel painted code-gauge sheet steel boxes with welded seams, hinged covers with stainless steel padlockable spring latch as manufactured by Hoffman Engineering Co. or approved equal. Provide sizes and configurations as indicated, or to suit job conditions and codes.

2. Outdoors or in wet areas, pull and junction boxes shall be NEMA 3R or NEMA 4 construction.

F. Telecommunications Terminal, Outlet and Pullboxes

1. Outlet boxes shall be galvanized sheet steel as described elsewhere in this Section with exceptions as noted hereafter. Desk type telephone and computer data outlet boxes shall be minimum size 4 11/16" square, 2-1/8" deep box with double gang faceplate and plaster ring. Outdoors: Cast boxes, NEMA FB1, Type FD, aluminum. Provide gasketed cover by box manufacturer and threaded hubs.

G. Floor Boxes

1. Provide floor boxes as indicated, suitable for the application, complete with compatible accessories including, but not limited to: trim rings, device plates, service fittings, tile or carpet flanges and protective rings for mechanical and wet mop protection.

2. Floor box fittings shall be equipped with gasketing and shall be constructed to meet or exceed UL scrub water exclusion requirements and be so listed.

3. Poke-through fittings shall be UL listed to maintain fire rating of floor construction. Do not use in new slabs unless specifically noted.

4. Floor boxes shall be cast iron for installation in slab-on-grade floors or wet floors, formed sheet steel for above-grade installations. Coordinate box depth with slab thickness and other job conditions. Boxes shall be adjustable before and after pour.

5. All floor boxes, regardless of whether poured-in-place or poke-thru types, shall be ADA-approved with regard to height above finished floor and surface slope ratio.

6. Where new floor boxes are indicated in existing floors, provide required saw-cutting and patching of existing floors as required for flush installation.

7. Coordinate specific non-power connectivity requirements with the Owner's Information Technology and Telecommunication System vendors.

8. Poured-in-place and wood floor boxes shall be provided in types as follows:

Label	Shape	Trim/Cover	Outlets	Description
Type 1	Square	Brass-BS [Aluminum-AL] [Black-BK] [Bronze-BZ] [Gray-GY]	Two duplex receptacles and data. [Provide with FPCTC** flanged cutout cover assembly for carpet/tile installation. Provide with FPBT** flangeless activation kit for wood/terrazzo installation.	Multi-service box for installation in new concrete slabs. Wiremold/Walker Series RFB4[-CI]. (3-7/16”D max.) Provide RFB4-SS series for shallow floors (2-7/16”D max.) Provide cast iron (CI) for slab on grade or wet locations unless otherwise noted.
Type 2	Square	Brass-BS [Aluminum-AL] [Black-BK] [Bronze-BZ] [Gray-GY]	Power and data. [Provide with FPFFTC** flanged cover assembly for carpet/tile installation.] [Provide with FPFFT** flangeless activation kit for wood/terrazzo installation.]	Multi-service furniture feed box for installation in new concrete slabs. Wiremold/Walker Series RFB4[-CI]. (3-7/16”D max.) Provide RFB4-SS series for shallow floors (2-7/16”D max.) Provide cast iron (CI) for slab on grade or wet locations unless otherwise noted.
Type 3	Square	Brass-BS [Aluminum-AL] [Black-BK] [Bronze-BZ] [Gray-GY]	Two duplex receptacles and data. [Provide with FPCTC** flanged cutout cover assembly for carpet/tile installation.] [Provide with FPBT** flangeless activation kit for wood/terrazzo installation.]	Multi-service box for installation in new concrete slabs. Wiremold/Walker Series RFB6[-CI]. (3-1/4”D max.) Provide cast iron (CI) for slab on grade or wet locations unless otherwise noted.
Type 4	Square	Brass [Aluminum]	Duplex receptacle per gang with #828R flip lid [#828SPTC screw-out] cover plate.	Single, double or three-gang box for concrete floors. Wiremold/Walker Series 880 Omnibox. (3-1/2”D max.) Provide 880M series for shallow floors (2-15/16”D max.)

Type 5	Square	Brass [Aluminum] [Plastic]	Duplex receptacle per gang with #828R flip lid [#828SPTC screw-out] cover plate	Single- or multi-gang modular plastic box for concrete floors. Wiremold/Walker Series 880MP Modulink. (field-adjustable depth)
Type 6	Square	Brass [Aluminum] [Plastic]	Duplex receptacle per gang with #828R flip lid [#828SPTC screw-out] cover plate	Single- or multi-gang box for wood floors. Wiremold/Walker Series 880W. (3-7/16”D max.)
Type 7	Round	Brass [Aluminum] [Plastic]	Duplex receptacle with #895 flip lid [#895SP screw-out] cover plate	Single-gang box for wood floors. Aluminum body for installation in 4” hole. Wiremold/Walker Series 861. (4-1/4” round x 3-1/4”D) max.
Type 8	Round	Brass [Aluminum] [Plastic]	Simplex receptacle with #825 screw-out cover plate	Small single-gang box for concrete floors. Wiremold/Walker Series 800. (2-5/8” round cover x 3-3/8”D) max.
Type 9	Square	Black [Brown][Gray] Plastic	Two duplex receptacles and data. Provide with AF1 Carpet [Tile] hinged cover plate	Multi-service box for installation in raised access floors. Wiremold/Walker Series AF1. (5”D max.) Series SAF1 for shallow floors (2.5”D max.)
Type 10	Square	Black [Beige] [Brown] [Gray]	Two duplex receptacles and data. Provide with Carpet [Tile] hinged cover plate.	Multi-service box for installation in raised access floors. T& B Steel City AFM-4 Series. (7-5/8” x 7-5/8” x 4”D)

9. Floor boxes for combination audio/visual and power work shall be provided in types as follows: [specified by the A-V/Theatrical Consultant.]

Label	Shape	Trim/Cover	Outlets	Description
Type 1V	Square	Brushed aluminum [Brass][Black][Oak], for carpeted [tiled] floors	Duplex IG receptacle and A/V. Steel flip-up cover with cable fold back slot.	Multi-service box for A/V and power installations in concrete slabs. 12.5"L x 10.5"W with interior angled brackets to provide mounting for power and signal receptacles. FSR, Inc., #FL-500P-*-** **Choose:* (Brass, S=Aluminum, BK=Black Paint, or OAK paint) **Choose:* (2.25, 3, 4, 6, 8, 10"D max.)
Type 2V	Square	Brushed aluminum [Brass][Black][Oak], for raised access floors	Duplex IG receptacle and A/V. Steel flip-up cover with cable fold back slot.	Multi-service box for A/V and power installations in raised access floors. 12.5"L x 10.5"W with interior angled brackets to provide mounting for power and signal receptacles. FSR, Inc., #FL-540P-*-** **Choose:* (Brass, S=Aluminum, BK=Black Paint, or OAK paint) **Choose:* (2.25, 3, 4, 6, 8, 10"D max.)

G. Where different voltage systems are indicated to occupy a common box, provide internal metal barriers or dividers between systems.

2.06 WIRING DEVICES

A. Provide switches, receptacles, connectors, and other wiring devices complete with associated hardware and wall plates, as indicated and specified. Devices of one type (such as switches and receptacles) shall be made by one manufacturer. Acceptable manufacturers are: Hubbell, Pass and Seymour (P&S), Cooper, Bryant or Leviton.

B. Verify device colors and plate materials and finishes with the Architect. Unless otherwise noted, receptacles connected to emergency or standby power shall be "red"; isolated ground receptacles shall be factory embossed with an "orange" triangle.

C. Wiring devices shall comply with applicable UL and NEMA requirements and shall be UL labeled for the appropriate NEMA-classified document.

D. Local Wall Switches (line voltage type)

1. Provide premium specification grade [Decora-style], quiet operating AC switches, rated 20 amperes at 120 volts. Switches shall be verified by UL to meet Federal Specification W-S-896E.

2. Provide single pole, double pole, 3-way, or 4-way operation as indicated or required.

3. Switches shall be Pass & Seymour HBL2621 series or approved equal.

E. Pilot Light Switches, 20 A, Single pole, with neon-lighted handle, illuminated when switch is "ON": Hubbell; HPL1221PL for 120 V and 277 V or approved equal.

F. Key-Operated Switches, 120/277 V, 20 A, Single pole, with factory-supplied key in lieu of switch handle: Hubbell; HBL1221L or approved equal.

G. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors: Hubbell; HBL1557 or approved equal.

H. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle: Hubbell; HBL1557L or approved equal.

I. Key-Operated Switches, 120/277 V, 20 A, Single pole, 3-position, maintained contact with factory-supplied key in lieu of switch handle: Leviton; 1285-L or approved equal.

J. Duplex Convenience Receptacles

1. Receptacles shall be standard NEMA 5-20R configuration.

2. Receptacles shall be two-pole, three-wire grounding type, with molded nylon body and face, premium specification grade, rated 20 amps at 125 volts. Receptacles shall meet Federal Specification W-C-596F.

3. Receptacles shall be Hubbell Inc. 5362, series or approved equal.

4. Where 15 ampere rated receptacles are indicated or required, provide Hubbell Inc. 5252, series or approved equal.

5. Provide weather-resistant (WR) receptacles for damp and wet locations.

6. Weatherproof lockable and flush covers for public outdoor, wet or damp location outlets shall be specification grade enclosures with neoprene gasket seals and mortar tabs for positive holding means and retains weatherproof feature with or without plug inserted. Provide Pass & Seymour heavy duty cast aluminum cover No. 4600 series or approved equal.

7. Weatherproof non-locking and flush covers for non-public outdoor, wet or damp location outlets shall be specification grade enclosures with neoprene gasket seals and retains weatherproof feature with or without plug inserted. Provide Arlington Products In Box Series or Taymac MX-3200 Series or approved equal.

8. Install receptacles with ground up or to the left when looking at receptacle.

K. Special Purpose Receptacles and Switches

1. Ground fault circuit interrupter (GFCI) receptacles shall comply with UL 2006 and shall be rated 20 amps with 20 amp feed-through rating, 125 volt duplex, NEMA 5-20R, Hubbell #GF20LA series, or approved equal.

2. Transient voltage surge suppression receptacles shall have integral metal oxide varistors rated: 150 volt rms, 80 joules energy absorption and 6,500 amperes current handling capacity minimum to suppress transients equally in all modes; 20 amp, 125 volt, NEMA 5-20R, LED indicator, Leviton #5380, Hubbell Circuit Guard #HBL 5360-SA series or Pass & Seymour SpecGuard #6362-SP series or approved equal. Receptacles shall be factory embossed with an “orange” triangle and LED indicator to assure protection is in place.

3. Isolated ground receptacles with integral surge suppression shall have an insulating barrier between the grounding screw and the mounting strap, and a triangle marking on the face to indicate isolated grounding type. The surge suppression unit shall have a light to indicate that the protection is active, and an audible alarm to indicate damage. The receptacles shall be NEMA 5-20R duplex, Leviton #5380-IG, Hubbell #IG-5362-SA series, P&S #IG6362-SP series or approved equal. Receptacles shall be factory embossed with an “orange” triangle.

4. Isolated ground receptacles without integral surge suppression shall have an insulating barrier between the grounding screw and the mounting strap and an orange triangle marking on the face to indicate isolated grounding type. The receptacles shall be NEMA 5-20R duplex, Hubbell #IG-5362 series, P&S IG6300 series or approved equal.

5. Clock hanger receptacles shall have a stainless steel plate and heavy duty 15 amp, 125 volt, grounding type receptacle, NEMA 5-15R, and shall be Hubbell Inc. HBL5235, P&S S3733-SS or approved equal.

6. Weatherproof switches shall be 20 amp, 120 or 277 volts, tap action with waterproof neoprene plate, specification grade, self-grounding, Cooper #2991 with #2881 plate or approved equal.

7. Break glass emergency shutdown switches shall be single-pole, double throw, flush or surface mounted, 5 amps at 250 volts, 10 amps at 125 volts, aluminum drip-proof construction, as follows:

   a. Chiller shutdown - ASCO #124202 (flush) or #124302 (surface) or approved equal.

   b. Boiler shutdown - ASCO #124201 (flush) or #124301 (surface) or approved equal. [Residential: Provide single pole, 20A wall switch and Mulberry type switch plate or approved equal.]

   c. Generator shutdown – ASCO #124204 (flush) or #124304 (surface), Pilla ST120 series or approved equal.

   d. Coordinate control wiring of break glass switches and the associated equipment with Division 23 work.

8. Push button emergency power off (EPO) switches shall be 2.375 inch mushroom head, non-illuminated, momentary push contact, labeled "Emergency Stop" in red, GE #CR104P Series or approved equal.

9. Door switches shall be push button type, 6 amps at 125 volts, flush mounted in hinged side of door where indicated on plans, switch closed when door open, Arrow Hart #4029, P&S #1200 or approved equal.

10. Lighted handle switches shall be illuminated when load is off, clear toggle, single or double poles or three-way, as indicated on plans, Hubbell Inc. HBL1221IL and HBL1223IL, P&S 20AC1-CPL and 20AC3-CPL series or approved equal.

11. Wallbox dimmers

    a. Provide wallbox dimmers rated for loads and voltages to be controlled. Do not gang-mount (mount side-by-side) dimmers in same box or remove side sections so that dimmers may be used up to full rating. Provide separate wall boxes unless otherwise specifically noted on plans.

    b. Dimmers shall be "3-way" capable, using "smart remotes" which allow dimming control from each switch location.

    c. Provide 1000-watt-rated Lutron Maestro series dimmers where used in the vicinity of Decora-style wiring devices and switches. Provide 1000-watt-rated Lutron Abella series dimmers where used in the vicinity of “standard” wiring devices and switches.

d. Provide Lutron remote Power Boosters and Hi-Power 2•4•6 Dimming Modules as required to increase wattage capacity of specified wallbox dimmers and to provide compatibility between specified dimmer style and loads to be controlled. Power boosters and Hi-Power 2•4•6 Dimming Modules shall be suitable for incandescent, fluorescent, magnetic low voltage, electronic low voltage or neon/cold cathode lamp sources. Provide sizes as indicated on the drawings, or as required to control loads indicated.

e. Provide dimming ballasts as required per Section 265000.

12. Occupancy/Vacancy Sensors

a. Sensors shall be automatic on (occupancy) or manual on (vacancy) as indicated on the drawings. Sensor operation shall incorporate dual technology digital passive infrared (PIR) detection to detect occupant motion and microphonic to detect occupant sound. Provide integral photocell to prevent lights from turning on if adequate daylight is available. Include a minimum on timer set at 15 minutes to preserve lamp life by eliminating short lamp cycles and a timer adjustable between 30 seconds and 20 minutes, and set at 10 minutes, to turn off if no occupancy is detected.

b. Ceiling mounted occupancy or vacancy sensor switches for single or multiple sensor operation with separately mounted auxiliary power and control unit. Sensor receives control power from the auxiliary power and control unit, and operates power switching contacts in that unit. Provide Sensor Switch CM-PDT 10 ceiling sensor with PP-20-2P series auxiliary power and control unit and sPOD-x series low voltage wall switch for Manual On operation, or Wattstopper DT-300 with BZ-Series power pack and DCC2 low voltage momentary wall switch with green LED for Manual On operation, or Cooper Greengate OMC-DT with switch pack and Model AML wall switch for Manual On operation. Provide additional relay/power packs as required for larger loads controlled by single sensor switches. Provide auxiliary power packs for HVAC control where indicated on the drawings.

c. Wall mounted occupancy or vacancy sensor switches for control of single circuit lighting loads shall be intelligent self-adjusting multi-technology types with integral manual “on” and “off” switch. Unit receives power directly from switch leg of the 120- or 277-V ac circuit it controls and operates integral power switching contacts rated 800 W at 120-V ac, and 1000 W at 277-V ac, minimum. Provide Sensor Switch WSD-PDT VA rated 120/277 volts, 800/1200 watts, Wattstopper DW-100, or Cooper Greengate ONW-D-1001-DMV NeoSwitch, or Hubbell AD1277.

d. Wall mounted occupancy or vacancy sensor switches for control of two circuit lighting loads (inboard/outboard lamp switching) or light and small fan loads shall be two pole intelligent self-adjusting types with integral manual override OFF switch. Provide Sensor Switch WSD-2P (first pole auto on/second pole manual on) rated 120/277 volts, 800/1200 watts, Wattstopper DW-200, or Hubbell AD1277x2.

L. Telecommunications Faceplates & Port Devices–Refer to IT Consultant's Documents.

M. Cable Television Outlets – Refer to IT Consultant's Documents.

N. Cover Plates

1. Provide compatible wall plate for each outlet and switch installed. Plates shall be .040" Type 302/304 stainless steel with brushed finish [specification-grade high-impact smooth nylon.] [High-impact nylon plates shall be as manufactured by Hubbell only.]. Color and finish to be selected by Architect. Refer to architectural/lighting consultant plans for engraving requirements. Submit sample to Architect and obtain acceptance prior to installation.

2. Where two or more switches or devices are indicated at one location, mount under common plate.

3. Exterior cover plates shall be gasketed heavy duty die-cast zinc, with spring loaded, self-closing gasketed lift cover which maintains weatherproof integrity while in use.

4. Screws shall be metallic, with countersunk heads, finish same as plate, tamperproof where indicated.

5. Telecommunication outlets shall have cover plates to match area wiring device type and accommodate port configuration in each wall or floor box. Refer to other Sections for exact types.

O. See other Division 26 sections for wallbox dimmers, low voltage switches, and other special-purpose devices.

2.07 GROUNDING MATERIALS

A. Provide a complete continuous grounding system to effectively ground the non-current carrying metal parts of every piece of installed equipment, and to provide a low impedance fault return to source.

B. Grounding materials shall be copper, bronze and/or brass construction with stainless steel or bronze threaded materials, listed and approved for the use. Cadmium or zinc-plated threaded materials are not acceptable.

C. Insulated grounding conductors shall be copper with green colored insulation, or black insulation totally covered with green vinyl tape at all taps and terminations, as permitted by NEC.

D. Conductors to be direct-buried or installed in ductbank, manholes and handholes shall be bare, tinned, stranded copper.

E. Connectors, clamps, straps, terminals, etc. shall be as manufactured by Burndy, Dossert, Ilsco or approved equal. Provide two-hole compression grounding lugs; one-hole lugs are not acceptable.

F. Ground rods shall be solid steel core with welded copper cladding (Copperweld or equivalent), 3/4" diameter x 10' long.

G. Provide factory kits for field-welded connections, Erico Cadweld, Thermoweld or approved equal.

H. Ground bus or grounding bars shall be bare annealed copper of rectangular cross-section, 2" wide x 1/4" thick unless otherwise indicated, complete with appropriate mounting hardware, clamps, and connectors. Hardware used with copper bar shall be silicon bronze.

I. Ground bars for the main telecommunications closet and satellite telecommunications closet grounding shall be tinned copper, with 304 stainless steel mounting brackets and hardware with 2-inch insulators and pre-drilled holes, as specified in ANSI J-STD-607-A. Manufacturer: Erico Eritech series or approved equal by Harger or Panduit.

1. Telecommunications main grounding busbar (TMGB) shall be 4" high x 1/4" deep x minimum 24" long. One TMGB shall be installed in the main telecommunications closet, or room.

2. Telecommunications grounding busbars (TGB's) shall be 2" high x 1/4" deep x minimum 18" long. TGB's shall be installed in each satellite telecommunications closet.

2.08 DISCONNECT SWITCHES

A. Provide safety switches where shown and required to comply with requirements of codes and enforcing agencies. Refer to Divisions 14 and 23 for additional

information and requirements. See other Division 26 sections for panelboard and switchboard applications.

B. Disconnect switches indicated by symbol of box with slash on drawings, for two and three-pole loads greater than 1/2 horsepower, shall be heavy duty NEMA Type HD complying with NEMA KS 1 with quick-make/quick-break blades, rejection fuse holders, and equipment grounding kit; enclosures shall be NEMA Type 1 (interior dry locations), NEMA 3R (outdoor locations), Type 4 (wet or damp indoor locations), Type 4X stainless steel (kitchen areas), Type 7C (hazardous locations) and as shown on drawings. Switches rated 1200 amperes and larger shall be bolted-pressure or high-pressure-contact type as shown on drawings, 100% rated, per UL 977. Disconnect switches shall have a listed interrupting capacity of no less than the interrupting capacity of the installed fuses, where applicable, and minimum of 100,000 amperes, unless otherwise noted.

1. Enclosures shall have hinged door with interlock to prevent unauthorized door opening when switch is in "on" position, or closing of switch with door open.

2. Ampere ratings, voltage ratings, fusing and poles shall be as indicated or required. Provide non-fused type unless otherwise noted.

3. Provision shall be made for padlocking in "off" position.

4. Where fusing is indicated, and unless otherwise specified, provide as follows:

   a. Main service and feeder switches 0 - 600 amperes: Class RK1; specification grade, Bussmann Low-Peak, dual element, time-delay, 200 kA, Type LPN-RK (250 volt) or LPS-RK (600 volt) or approved equal by Ferraz Shawmut.

   b. Main service and feeder switches 601 - 6000 amperes: Class L; Bussmann Low-Peak, Type KRP-CSP, 600 volt, time-delay, 300 kA, or approved equal by Gould - Shawmut.

   c. Motor and transformer branch circuits 0 - 600 amperes: Class RK5; Bussmann Fusetron, Type FRN-R (250 volt) or FRS-R (600 volt), time delay, 200 kA, or approved equal by Ferraz Shawmut.

   d. Motor and transformer branch circuits 601 - 6000 amperes: Class L; Bussmann Low-Peak, Type KRP-C, 600 volt, time delay, 200 kA, or approved equal by Ferraz Shawmut.

e. Non-motor branch circuits 0 - 600 amperes: Class J; Bussmann Low-Peak Type LPJ, 600 volt, dual element, time-delay, 200 kA, or approved equal by Ferraz Shawmut.

5. Fuses shall be of the same manufacturer.

6. Provide three (3) spare fuses of each type and size installed, in manufacturer's original packaging.

C. Disconnect switches indicated by symbol SM on drawings, for single-phase, one or two-pole loads, 1/2 horsepower and less, shall be toggle-type, AC manual motor starting switches with thermal overload protection to match the motor served. Switches shall be U.L. 508 Listed.

1. Single-pole switches shall be rated 30 amperes at 120-240 VAC, 2 HP at 120 volts, 3 HP at 240 volts, with standard toggle with brown handle. Provide key-type or pilot light types where specifically indicated. Mount with appropriate backbox and coverplate per Section 2.02; NEMA 1 where indoors; NEMA 4 where outdoors. Square D Type FO1 or approved equal.

2. Two-pole switches shall be rated 30 amperes at 240 VAC (3 HP at 120 volts, 7.5 HP at 240 volts). Provide manufacturer's standard NEMA 1 enclosure where indoors; NEMA 4 enclosure where outdoors enclosure for each unless otherwise noted. Square D Type FO2 or approved equal.

D. Provide accessory dry contacts in disconnect switches:

1. For motors controlled by an electronic variable frequency drive unit. Provide interlock wiring from auxiliary contacts to drive "Run-Permit" circuit to prevent drive from attempting to start motor with remote disconnect open.

E. Mount disconnect switches 4'-6" above finished floor to center of operating handle.

F. Fire pump disconnect switches shall be lockable in the on and off positions with 2 sets of normally open and normally closed Form C contacts rated 4 amperes @ 30 volts DC. Provide connections for switch open or tripped to signal a trouble alarm at the fire alarm control panel [and to interrupt the fire pump ATS emergency generator start circuit,] and provide a status signal to the Building Management/Automation System (BMS/BAS). Switches shall be service-entrance rated where required by Code.

G. Fire alarm control panel disconnect switches shall be lockable in the on and off positions with red identification.

2.09 ENCLOSED CIRCUIT BREAKERS

1. Where protective devices are indicated to be enclosed circuit breakers, provide manually-operated stationary mounting molded case circuit breakers up to and including 1200 ampere frame. Provide insulated case, fixed mounting circuit breakers above 1200 ampere unless otherwise indicated on the drawings. Circuit breakers shall be U.L. listed and labeled. See other Division 26 sections for panelboard and switchboard applications.

2. Provide 100% rated circuit breakers where indicated for application at 100% of the breaker's continuous current rating and UL 489 compliant. Circuit breaker shall be marked: 'Suitable for continuous operation at 100 percent of rating'.

3. Frame and trip ratings shall be as indicated. Circuit breakers 200A and larger shall have field-interchangeable trip units within frame size. Circuit breakers 400AF and larger shall have field-adjustable electronic trip units, with field-interchangeable rating plugs within frame size.

4. Electronic trip units shall include and display the following protective functions and features:

    a. Adjustable long-time pickup and delay.
    b. Adjustable short-time pickup and delay.
    c. Adjustable instantaneous pickup (up to 10X).
    d. Trip target for each function.
    e. Voltage on each phase.
    f. Instantaneous current on each phase.
    g. Kilowatt hours & kilowatt demand.
    h. Instantaneous kVA & kVA demand.
    i. Power factor.
    j. Harmonic distortion.
    k. Phase failure.
    l. Shunt trip where indicated.
    m. Adjustable ground-fault pickup and delay (up to 1200 amperes pickup) where indicated.
    n. Arc-fault where indicated.

5. Provide circuit breakers with handle locking devices and padlocking hasps.

6. Enclosures: NEMA AB 1, Type 1 unless otherwise indicated or required to meet environmental conditions of installed location and as follows:

   a. Outdoor Locations: Type 3R.
   b. Kitchen Areas: Type 4X, stainless steel.
   c. Other Wet or Damp Indoor Locations: Type 4.
   d. Hazardous Areas Indicated on Drawings: Type 7C.

2.10 SPD – SURGE PROTECTION DEVICES

A. Provide surge suppression devices where indicated on the drawings. Equipment shall be manufactured by a single manufacturer and listed to the following standards:

   a. UL 1449, 3rd Edition updates effective September 29, 2009 “Surge Protective Devices”.
   b. UL 1283 “Electromagnetic Interference Filters”.
   c. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
   d. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
   e. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
   f. National Electrical Code: Article 285.
   g. SPD shall be UL labeled with 20kA nominal rating (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.

B. SPD manufacturer shall have at least five (5) years experience in manufacturing surge protection devices and shall be ISO 9001 or 9002 certified.

C. Surge protection devices shall be connected on the load side of utility metering compartment and shall comply with local utility requirements.

D. SPD shall provide Standard 7 Mode Protection paths for modes of protection as follows:

   a. Wye systems: Normal mode suppression line-to-line, line-to-neutral, common mode suppression line-to-ground and neutral-to-ground.

   b. Delta and impedance grounded wye systems: Line-to-line and line-to-ground.

E. Submittals shall include information describing each unit and as a minimum establish compliance with the following criteria:

F. UL listed and labeled as Type 1 intended for Type 1 or Type 2 applications as follows:

a. Service entrance: 300 kA per phase and 200 kA short circuit current rating (SCCR).
b. Distribution: 100 kA per phase and 200 kA short circuit current rating (SCCR).
c. Branch: 100 kA per phase and 65 kA short circuit current rating (SCCR).

G. Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200 V	1200 V	2000V	320V

H. Maximum Continuous Operating Voltage (MCOV):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277	15%	320V

I. Suppression components shall be heavy duty metal oxide varistors and shall be field replaceable module(s) (service entrance only).

J. Audible noise: 35db or less @ 3 feet from unit.

K. Response time less than or equal to ½ nanosecond.

L. UL 1283 listed EMI/RFI filter with noise attenuation: -50dB or greater at 100 kHz.

M. Fusing: 200 kA symmetrical fault current interrupting capacity @ 600V.

N. Phase and operational status indicator LED indicator lights for power and protection status.

O. Surge counter (service entrance only).

P. NEMA 1 enclosure with safety interlocked entry door.

Q. Integral circuit breaker or fused disconnect switch (service entrance only).

R. Dual set of Form C dry contacts for remote monitoring.

S. Audible alarm & alarm disable.

T. Approved manufacturers: Current Technology, Liebert, Siemens Industry, Inc. or Advanced Protection Technologies.

2.11 CONDUIT AND CABLE SEALING BUSHINGS

A. Conduit sealing bushings for sealing conduit penetrations against fluid and air pressure shall be as follows as manufactured by O.Z. Gedney, Thunderline Corporation, Burndy or Thomas & Betts.

1. For walls which have or will have membrane waterproofing:
   a. Cast-In-Place Installations: OZ/Gedney Co.'s Type FSK thru wall seal and Type FSKA membrane clamp adapter.
   b. Core drilled or Sleeved Installations: OZ/Gedney Co.'s type CSM and type CSMC with membrane clamp adapter.

2. For walls which will not have membrane waterproofing:
   a. Cast-In-Place Installations: OZ/Gedney Co.'s Type FSK.
   b. Core Drilled or Sleeved Installations: OZ/Gedney Co.'s Type CSM or Thunderline Corporation Link-Seal CS-316.

3. Provide abandonment plates for unused openings.

B. Cable sealing bushings for sealing power cables in conduit shall be Type CSB, by O.Z. Gedney, Burndy or Thomas & Betts.

C. Cable seals for low voltage and signal cables shall be reusable simplex, duplex or triplex split design as required by Tyco Electronics or approved equal. Empty/spare conduit closed end caps shall be low temperature shrink Type LTCP by Tyco Electronics Raychem or approved equal.

2.12 UNDERGROUND LINE IDENTIFICATION MARKER TAPE

A. Underground line identification marker tape shall consist of a reinforced protective plastic jacket bonded to an electronically detectable solid aluminum foil core constructed in a tape type format.

B. The product shall be resistant to acids and alkalis commonly found in soil.

C. The tape shall be minimum 6" wide.

D. The tape shall be installed 12" below finished grade, directly above the buried raceway or cables.

E. The following stock imprinting shall be provided:

1. "CAUTION Telephone Buried Below!", for telecommunications duct banks, direct burial cable and/or conduits. Use black letters on orange background.

2. "CAUTION Electric Line Buried Below!", for electrical duct banks, direct burial cable and/or conduits. Use black letters on red background.

F. Provide custom imprinting where indicated, or where necessary to suit special applications.

G. Provide products manufactured by Reef Industries, Inc., Terra Tape Sentry Line 1350 or approved equal by Ideal.

2.13 SUBMETERING

A. Provide UL listed Amps/Volts/kW/kW peak/power factor/kWh/KVARh/Demand submetering equipment where indicated on the drawings. Data for two channels shall be stored in 15-minute intervals for 36 days or 5-minute intervals for 12 days. Metering shall be 1% accurate, fully electronic with LCD display for kilowatt hour and demand readings with low and high user selectable set points and mounted in a lockable NEMA 1 enclosure. Provide voltage and split core type current sensors that shall be capable of remote mounting up to 500 feet from meter and suitable for installation in panelboards, switchboards or remotely mounted in separate enclosures as indicated without interrupting circuit continuity. Each meter shall be capable of reading up to (3) sets of current sensors for cumulative (totalizing) readings of 120/208V or 277/480V, and three phase, 3-wire and 4-wire systems. Provide the following communications accessories: [Telephone Modem][RS-232/RS-432][Ethernet][ModBus][load control alarm relay with high and low threshold adjustment] via 4-conductor 24 AWG cable up to 4000 feet. Submetering equipment shall be E-MON Corporation Class 3000 Series or approved equal.

2.14 SECURITY SYSTEM – Refer to Security Consultant's documents.

2.15 AUDIO-VIDEO SYSTEM – Refer to Theater Consultant's documents.

2.16 TELECOMMUNICATION SYSTEM – Refer to IT Consultant's documents.

2.17 CABLE TELEVISION (CATV) SYSTEM – Refer to IT Consultant's documents.

2.18 SHUNT RELAY DEVICES

A. Provide shunt relay devices to power egress lighting regardless of fixture switch position where indicated on the drawings. The device shall be capable of shunting around the local control including switch, dimmer, occupancy sensor or relay when normal utility power has been lost. An un-switched source of power on the same branch circuit as the AC ballast is required. The device shall not affect normal fixture operation when wired to a direct, un-switched connection to a generator-supplied or central inverter-supplied lighting circuit.

B. The shunt relay device shall be a normally-closed, electrically-held relay wired in parallel with wall switch as detailed on drawings. Operation shall be such that the manually controlled emergency lighting shall be automatically energized “on” during a power outage. Relay shall fit in a 4” x 4” x 2.125” junction box, maximum 1 watt power consumption, 120V or 277V coil rating as required, 20A contact rating up to 277V, UL 916 and UL924 compliant. Manufacturer: Lighting Controls & Design (LC&D) Emergency Shunt Relay or approved equal.

C. Refer to details on drawings for relay types and control configurations.

PART 3 - EXECUTION

3.01 WIRING & RACEWAY - GENERAL

A. The drawings show the general layout and typical details. Provide complete systems. Drawings are based on the specified equipment. Raceway layouts, boxes, and wiring of the systems are subject to approved shop drawings.

B. Ensure that items to be furnished fit the space available. Make necessary field measurements to ascertain space requirements, including those for connections, and provide such sizes and shapes of equipment that final installation shall satisfy the intent of the drawings and specifications.

C. Locations of outlets, switches, appliances, etc. as shown on Electrical plans are approximate; coordinate with Architectural and Mechanical plans and details, and with job conditions. Install switches with "OFF" position down and on the strike side of doors, unless otherwise noted. Install receptacles with grounding pole in the up position for vertical mounting and at left for horizontal mounting.

D. Locate and install electrical equipment, junction and pull boxes, panelboards, switches, controls, and other apparatus requiring maintenance, inspection, and operation so as to be readily accessible. For finished locations, provide a suitable marked, hinged access panel only where approved by the architect.

3.02 RACEWAY INSTALLATION

A. Install conduit in accordance with the NECA "Standard of Installation".

1. In architecturally finished spaces, conduits and cables shall be run concealed in hung or furred ceilings, slabs, masonry, and partitions unless otherwise indicated. In unfinished spaces, raceways may be run exposed.

2. Raceway installation at existing slabs, existing masonry walls and existing furred partitions in finished areas shall be as indicated in the raceway schedule listed in paragraph 2.01, saw-cut or chopped into existing floor or partition and patched, unless otherwise specifically noted. Surface raceways shall only be used where specifically indicated or permitted by the Architect.

3. Submit shop drawings for exposed conduits or raceways indicated on drawings in architecturally finished spaces.

4. Shop drawings shall demonstrate coordination with related trades and the ability to provide a neat and workmanlike installation.

B. Unless otherwise indicated, exact routing of raceways shall be determined by the Contractor to suit project requirements and field conditions.

C. Where raceways cross expansion or seismic joints, provide approved expansion fittings, or combinations of fittings, which allow deflection in all directions equal to twice the movement allowed in the structural design. For conduits 1-1/4" trade size or smaller, a 24" length of flexible metal conduit, with bonding jumper, slack mounted, may be used.

D. Provide sealing bushings on the ends of underground conduits that terminate at indoor equipment, or interior conduits where subject to different temperatures or where condensation is known to be a problem as in cold storage areas. Install appropriate sealant after installation and testing of cables.

E. Raceways and cables shall be neatly arranged on hangers and supports, with fittings designed for the purpose, and shall be installed parallel and perpendicular to walls, floors, structure and ceilings in a neat and workmanlike manner. Group related raceways; provide space for 25 percent additional raceways.

F. Raceways installed in close proximity to pipes of other trades shall be arranged to allow proper clearance for servicing, headroom and the like. Maintain minimum 6 inch clearance from steam, hot water, and flue piping.

G. Conduit ends shall be reamed smooth and interiors shall be wiped clean and dry.

H. Use of running threads is not permitted; use conduit unions or split couplings in areas where threaded conduit cannot be turned.

I. Conduits passing through roof construction shall be flashed watertight.

J. Raceways shall be supported at intervals less than or equal to code with seismic bracing as described in this section.

K. Locate pull boxes, junction boxes, pull fittings, etc. to comply with code and to prevent recommended values of wire and cable tensions and side wall pressures from being exceeded.

L. Conduit in concrete or masonry shall be securely held in place during pouring and construction operations. Change from non-metallic conduit to rigid steel conduit before rising above the floor or emerging from concrete.

M. Where conduits are embedded in concrete above metal decking or suspended below metal decking, provide spacers for 1-1/2 inch minimum gap between conduit and deck to avoid penetration of conduit by fasteners.

N. Direct buried conduit and conduit below concrete slabs: Unless otherwise shown on the plans, a layer of fine earth material, at least 4 inches thick (loose measurement) shall be placed in the bottom of the trench as bedding for the conduit. The bedding material shall consist of soft dirt, sand or other fine fill, and it shall contain no particles that would be retained on a 1/4-inch sieve. The bedding material shall be tamped until firm. Flowable backfill may alternatively used. Backfill using fine material no less than 6 inches above the top of the conduit placed in 6-inch lifts and thoroughly tamped.

O. Provide a suitable pullstring in each empty conduit except sleeves and nipples less than 24 inches.

P. Use suitable caps to protect empty conduit against entry of dirt and moisture.

Q. Conduits and/or sleeves shall not be placed in concrete slabs or walls without prior approval of the Architect. Prepare a submittal detailing the number, size, spacing and layout of the proposed conduit and/or sleeves including material specifications. Adhere to the following limits in planning the conduit embedments:

1. Maximum outside diameter of embedded conduit or sleeve: ¼ the thickness of the slab or wall.
2. Minimum center-to-center conduit spacing: Six (6) times the outside diameter of the conduit.
3. Conduits shall be firmly supported at the mid-thickness of the slab or wall and shall be wired into place.

4. Conduits shall not be placed in contact with the concrete reinforcement.
5. Use of aluminum conduit or sleeves for embedment in concrete is not permitted.
6. Conduit or sleeves shall not be placed in columns or beams.

R. Close ends of conduits immediately after being placed to keep out foreign matter. The entire conduit system shall be tested for obstructions, omissions and smooth joints by fishwire, and thoroughly swabbed out and made dry before pulling any wire.

S. Install covers on boxes and raceway fittings. Plug unused open knockouts and hubs.

T. Do not install outlet boxes back-to-back in walls. The use of thru-wall boxes is strictly prohibited.

U. Provide phenolic insulating connectors for metal conduits containing BOTH normal ground AND isolated-ground conductors, where the conduit is NOT being used as the equipment grounding conductor. (For conduits containing only a normal ground conductor or only an isolated ground conductor, where the conduit is also used as the equipment grounding conductor, provide galvanized couplings and connectors.)

V. Provide separate raceways, junction boxes, pull boxes and wireways for emergency system wiring.

W. Optical Fiber/Communications Cable Raceway and fittings shall not be run exposed, in concrete slabs or direct buried in earth except as shown on drawings. Color code: ORANGE for communications.

3.03 WIRING INSTALLATION

A. Do not use wire smaller than No. 12 AWG for any power or lighting circuit. Use larger sizes where indicated, as required by codes, and as follows:

1. 30 ampere circuit: No. 10
   40 ampere circuit: No. 8
   50 ampere circuit: No. 6
   60 ampere circuit: No. 6

2. Minimum homerun and branch circuit wiring sizes and maximum homerun conduit fill for 120 Volt, 20 ampere circuits shall be as follows:

Length	Circuit Wire Size	Home Run Wire Size	Conduit Size (9 current-carrying conds.+ G)
0' to 50'	#12	#12	3/4"
51' to 100'	#12	#10	3/4"
101' to 200'	#10	#8	1" (1-1/4" for 9 #8 AWG +G)

Greater than 200' - Request Direction from Architect.

3. Home runs and branch circuit wiring for 277 Volt, 20 ampere circuits shall be as follows:

Length	Circuit Wire Size	Home Run Wire Size	Conduit Size (9 current-carrying conds.+ G)
0' to 100'	#12	#12	3/4"
101' to 200'	#10	#10	3/4"

Greater than 200' - Request Direction from Architect.

Note: Provide derating per Code when installing more than 3 current-carrying conductors in conduit.

B. Do not use wire smaller than No. 14 AWG for control circuits unless otherwise recommended by the equipment or system manufacturer on wiring shop drawings, and so approved by the Architect.

C. Where greater than three (3) current-carrying conductors are installed in any one conduit or cable, conductors must be derated and sizes increased, if needed, to accommodate conductor derating as required by NEC Article 310.15(B)(2)(a) Allowable Ampacities of Insulated Conductors Rated 0-2000 volts. Do not install more than nine (9) current-carrying conductors in conduit or raceway without approval from the Engineer.

D. Where conductors in conduits supported above roofs are exposed to sunlight, apply ambient temperature ampacity adjustment factors per Table 310.15(B)(2)(c) according to distance above roof from bottom of conduit.

E. Make splices only at outlets or accessible junction boxes. Make splices No. 10 AWG and smaller with Buchanan B-Cap wire-nuts or equivalent insulated

solderless twist-on connectors. Make joints, taps, and splices in wires No. 8 AWG and larger with solderless mechanical connectors enclosed in molded covers. Splices shall be UL listed for the environment.

F. When pulling conductors through conduits, care shall be taken not to exceed manufacturer's maximum tension and side wall pressures.

G. Wire shall not be installed until work which may cause injury to wiring has been completed, and conduits are cleaned and dry.

H. Conductors shall be completely installed and connected. Provide terminals, lugs, and connectors to suit the application, and in compliance with equipment manufacturers' recommendations.

I. Branch circuit wiring for lighting and other single phase applications shall be multi-wire, utilizing common neutrals, except dimmer circuits shall have separate neutrals, and as otherwise indicated.

1. Under no circumstances shall any switch or circuit breaker break a neutral conductor.

2. The circuit numbers indicated on the drawings are intended as a guide for proper connection of circuits at panels. However, it shall be the responsibility of the Contractor to ensure that the final circuiting work fulfills the following conditions:

a. Loads on panel busses shall be phase-balanced as evenly as possible.

b. No neutral conductor shall be common to more than one circuit conductor of the same phase leg.

3. Receptacle, fluorescent lighting, and electronic low voltage lighting (track or fixed) branch circuits shall be considered non-linear loads and shall be provided with [either] individual dedicated 100% neutral wires[, or a common neutral wire sized at 173% ampacity of the phase wires].

4. Provide multi-pole circuit breakers for multi-wire circuits and circuits that supply devices or equipment on the same yoke or strap.

J. Wire lubricant shall be used to ease the pulling of cables and conductors in conduits. The lubricant used shall be fully compatible with the wire insulation or cable jacket material.

K. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.

1. Color-code 208Y/120-V system as follows:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White.
   e. Ground: Green.

2. Color-code 480Y/277-V system as follows:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: White with a colored stripe or gray.
   e. Ground: Green with a yellow stripe.

3.04 GROUNDING & BONDING INSTALLATION

A. Install a complete building, equipment, and system grounding and bonding network as indicated and specified, and to meet or exceed the requirements of NEC Article 250 and the local utility.

B. Grounding Electrode System

1. Install a buried and looped bare tinned copper #4/0 AWG grounding electrode conductor to (4) equally spaced ground rods located outside the building electrical service entrance, 18-24 inches below finished grade. Connect both ends of the looped bare tinned copper #4/0 AWG grounding electrode conductor to the service equipment ground bus.

2. Bond structural steel and interior metal piping at accessible points to the grounding electrode system. Size bonding conductors per NEC. Interior metal piping to bond includes: water, fire protection, gas, waste, drain, vent, pneumatic, oxygen, air and vacuum systems.

3. Install a concrete-encased (Ufer) electrode located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth. Electrode shall consist of 25’ minimum of bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods not less than ½” in diameter, or of 25’ of #4/0 AWG bare copper conductor.

4. Install grounding electrode system at each remote building or structure supplied from the main building electric service where the remote building or structure is supplied by more than a single branch circuit – see NEC Article 250.32 (A).

5. Where applicable, bond lightning protection grounds to the ground loop.

6. After completion of installation, test earth ground resistance by fall-of-potential or other approved method. If test result is greater than 3 ohms, drive two (2) additional ground rods and bond to system. Provide a certified report of the test methods and results, including any corrective actions taken. Do not use salt or other chemical means to reduce earth resistance, unless so directed by the Architect.

C. System Grounding

1. Bond the service entrance grounded conductor to the looped bare tinned copper grounding grid. Size conductors per NEC, but use no smaller than No. 4 AWG.

2. Where applicable, bond the secondary neutral terminal (X_0) and tank grounding pad of the outdoor transformer to the transformer grounding grid and to the service grounding point as shown on the drawings. Size conductors per NEC, but use no smaller than No. 4 AWG unless otherwise shown on the drawings.

3. Generator systems with 3-pole transfer switches: Remove the neutral bonding link between the neutral (X_0) terminal and the equipment grounding terminal of the generator. Connect generator equipment grounding conductor to the building ground electrode for indoor and outdoor installations. Do not install supplemental ground rods. Size conductors per NEC, but use no smaller than No. 4 AWG.

4. Generator systems with 4-pole transfer switches: Install a neutral bonding link between the neutral (X_0) terminal and the equipment grounding terminal of the generator. Connect generator equipment grounding conductor to the building ground electrode for indoor installations. Additionally, for outdoor installations, provide a supplemental ground rod. Size conductors per NEC, but use no smaller than No. 4 AWG.

D. Equipment Grounding

1. Install an insulated ground conductor, run in the raceway with the phase conductors, for each feeder serving: panelboards, lighting dimmer boards, motor control centers, motors, equipment and appliances unless otherwise noted.

2. Include an insulated ground conductor in conduit runs containing sections of flexible conduit unless otherwise noted.

3. Include an insulated ground conductor in branch circuit raceways or cables unless otherwise noted.

4. Note: Addition of equipment grounding conductor to AC circuits run in metallic enclosures does not lessen the requirement for conductor enclosure continuity, since part of total ground fault current will flow through the raceway and enclosure system. Therefore, the continuity of this system shall be maintained.

5. Provide bonding bushings and bonding conductors for boxes with concentric, eccentric or over-sized knockouts. The bonding conductor shall be sized per NEC Table 250-122 and lugged to the box.

6. Grounded service conductor (neutral) of distribution system shall be grounded at only one point: service neutral connection to the ground bus. Under no circumstances shall system neutral be grounded at any other point. As part of final inspection procedures, demonstrate purity of system neutral.

7. Bond each separately derived system transformer. Bond grounded conductor (X0) to the transformer case, to the nearest available interior metal water piping, to nearest grounded building steel, and to other metal piping in accordance with requirements of NEC Article 250. If building steel does not exist (i.e., concrete structures), the transformer shall be grounded to main service ground bus. Size conductors per NEC, but use no smaller than No. 4 AWG copper unless otherwise shown on the drawings. The transformer primary feeder ground is supplemental and shall be sized for primary feeder protection. Refer to contract drawings for additional bonding requirements.

8. Install a common grounding electrode conductor serving each separately derived system. The common ground electrode conductor size shall be #3/0 ASW bare tinned copper. Taps to each separately derived system shall be sized per NEC Table 250.66 and minimum #6 AWG bare copper.

9. Include a driven ground rod at each outdoor lighting standard (lighting pole mounted on concrete pedestal base). Provide #8AWG bare grounding electrode conductor from ground rod through sleeve in concrete pedestal to grounding bushings on metallic conduit stubs within light pole, and to pole grounding terminal. Grounding connections shall be accessible from pole handhole.

E. Low Voltage Telecommunications Grounding & Bonding

1. Provide a proper grounding and bonding infrastructure serving low voltage telecommunications systems including voice, data, video, audio, fire alarm, security and environmental control per ANSI-J-STD-607-A as indicated on the drawings and as follows:

a. Provide a Telecommunications Bonding Backbone (TBB), minimum size #3/0 AWG in 1-inch conduit from the main service grounding electrode system to the Telecommunications Main Grounding Busbar (TMGB) and to each Telecommunications Closet Busbar (TGB). The intent of the TBB is to reduce or equalize potential differences between telecommunications systems.

b. Where two or more vertical Telecommunications Bonding Backbones (TBB) are used in a multi-story building, provide a #3/0 AWG horizontal grounding equalizer (GE) to each TBB at the top floor, bottom floor and every third floor.

c. Metallic raceways for low voltage telecommunications systems copper or fiber optic cabling shall be made electrically continuous for grounding purposes and bonded to the TGB or TMGB. Provide connections from each item to the ground bus or if bonded in series provide a connection at each end for continuity.

d. Bonds shall be hollow braided copper jumpers minimum 60A ampacity. Each bond terminal shall be irreversible compression type with NEMA two-hole bolted connections to ground bus or exothermic weld connection.

e. Provide additional #4 AWG ground cable connections from each TMGB and TGB to the closest building steel and to the ground bus in the electric panel serving the outlets and equipment in the associated telecommunications room/closet.

f. Ground each low voltage system to the TMGB or TGB with a #4 AWG conductor.

g. Grounding and bonding conductors shall be installed without splices. Exception: Irreversible compression-type connectors or exothermic welds.

h. Conductors may be insulated; if insulated the insulation shall meet the fire ratings of its pathway.

2. Grounding or bonding conductors installed for Telecommunications Systems shall be labeled near their termination points. Labels shall be non-metallic and include the following:

a. “WARNING if this connector or cable is loose or must be removed, please call the Building Telecommunications Manager.”

b. Labels and installation shall meet the requirements of ANSI/TIA/EIA 606 and 607.

F. Specialty Grounding

1. Provide ground connections for anti-static floor covering materials according to manufacturer's installation instructions.

2. Audio Isolated Ground Test - Verify the integrity of the audio isolated ground system, as specified by the AV Consultant, and as follows:

a. Confirm that continuity is measured between each isolated ground receptacle/outlet neutral conductor and the grounding electrode connection at the audio isolation transformer.

b. Disconnect the neutral bonding link at each audio isolation transformer and confirm that the neutral buss is isolated from the building ground. Locate and remove connections between the neutral buss and the building ground other than the main bonding jumper. Reconnect the neutral bonding link.

c. Confirm that continuity is measured between each isolated ground receptacle/outlet ground conductor and the grounding electrode at the audio isolation transformer.

d. Disconnect the isolated ground bonding link at each audio isolation transformer and confirm that the isolated ground buss is isolated from the building ground. Locate and remove connections between the isolated ground buss and the building ground other than the main bonding jumper. Reconnect the isolated ground bonding link.

e. Confirm that each isolated ground receptacle/outlet is wired with correct polarity.

3.05 RACEWAYS FOR TELECOMMUNICATION SYSTEMS – Refer to IT Consultant documents.

3.06 RACEWAYS FOR CATV SYSTEM – Refer to IT Consultant documents.

3.07 RACEWAYS FOR SECURITY SYSTEM – Refer to Security Consultant documents.

3.08 RACEWAYS FOR AUDIO-VIDEO SYSTEMS – Refer to A-V Consultant documents.

3.09 MECHANICAL EQUIPMENT WIRING

A. Unless otherwise indicated or specified herein, motors, motor starters, motor controllers, variable speed/frequency drives, and associated control devices are furnished by other Divisions and installed by this Division. Coordinate installation and locations with other Division contractors.

B. Power wiring from the indicated source to the starter/controller/drive unit, and from the starter/controller/drive unit to the motor, including any local disconnect switches provided and installed by this Division, and associated lugs, terminals, and connections, is the work of this Division.

C. Verify correct voltage, phase rotation and protection for equipment prior to start-up. Correct deficiencies before energizing equipment.

D. Control circuit wiring is generally furnished and installed under other Divisions, except that any such wiring shown on Electrical drawings is work of this Division.

E. Provide 120 volt power to temperature control panels (TCP's) supplied and installed by Division 23. Use emergency power sources when available. Coordinate power requirements and panel locations with Division 23 Temperature Controls Contractor.

F. Cooperate and coordinate with the other trades in the installation, connection, and testing of mechanical equipment. Perform work of this section in accordance with equipment manufacturers' instructions.

3.10 FIRE PUMP WIRING

A. Provide power, emergency generator starting, and supervisory alarm wiring to/from the fire pump controller and automatic transfer switch furnished and installed by the Division 21 fire protection contractor.

B. Service conductors from the utility to the fire pump normal power service shall be physically routed outside the building, or encased in a minimum of 2” of concrete or brick per NEC 695.6(A).

C. Power wiring from the normal power service to the fire pump controller shall be installed using one of the following methods per NEC Article 695.6(B):

1. Encased in a minimum of 2” of concrete
2. Run with an enclosed construction dedicated to the fire pump circuit and having a minimum of a 1-hour fire resistive rating

3. A listed electrical circuit protective system with a minimum 1-hour fire rating.

Refer to drawings for method to be used and obtain approval from engineer for any deviations.

D. Overcurrent protection for the normal power source to the fire pump shall be rated to carry the sum of the locked-rotor current of the pump motor, and any accessories on the same circuit, indefinitely.

E. Disconnect switches and overcurrent protection for both normal and emergency power sources shall be lockable in the closed position. Refer to paragraph 2.08G for other fire pump disconnect switch requirements.

F. Provide start signal wiring and conduit as required from the fire pump controller and automatic transfer switch to the emergency generator to start the generator in the event of a utility power failure.

G. Provide supervisory alarm wiring from the fire pump controller to the fire alarm system. Supervisory alarms to be wired are: power failure alarm, phase reversal alarm, and pump running alarm.

H. Coordinate all wiring and interfaces with the Division 21 fire protection contractor. Coordinate all alarm and starting contact voltages, ratings, and types (NO/NC) with the equipment being supplied.

I. Provide 6 conductors plus ground from the fire pump controller/starter to the pump motor for pumps utilizing wye-delta starters – coordinate with Division 21 fire protection contractor.

3.11 SUPPORTS AND HANGERS

A. Provide metal framing, supports and braces for equipment installed. Provide floor mounted or free standing supports for equipment not mounted to concrete or block walls. Support panelboards, pull boxes and outlet boxes independently of the conduit.

B. Support single conduit runs by individual hangers.

C. Support multiple conduit runs on trapeze hangers. Do not support conduit on hangers provided for mechanical runs.

D. Provide listed raceway roof support blocks. Wooden support blocks are not acceptable.

E. Securely fasten electrical items including lighting fixtures and their supports to the building structure, unless otherwise indicated. Do not use the ceiling-support wires or ceiling grid to support raceways and cables. Provide independent support wires, secured at both ends.

F. Do not support electrical items including disconnect switches, motor controllers, variable frequency drives, or conduit from the equipment or supports of other divisions.

G. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Do not support electrical items from the equipment or supports of other divisions.

H. Hanger rods shall be threaded galvanized steel, 3/8" minimum with galvanized double nuts, securely attached to the building structure. Provide sizes, quantities, and connections to safely support imposed loads.

I. Support horizontal and vertical conduits per code and to prevent visible deflections. Conduit shall be firmly fastened within 3 feet of each outlet box, junction box, cabinet or fitting.

J. Provide galvanized steel channel or angle as required for conduit and equipment supports. Provide independent support for items weighing 100 pounds, or more, mounted on gypsum board partitions.

K. Connect rod hangers to the building structure as follows:

1. In formed concrete slabs provide anchors by means of cast-in-place inserts.

2. To structural steel provide anchors secured to the structure with beam clamps. Clip type (Caddy) conduit supports shall be used only for armored cable.

3. To existing work provide expansion bolts if structural steel is not available.

4. Powder propelled inserts are not acceptable for this project.

3.12 HOUSEKEEPING PADS AND RUBBER MATS

A. Provide concrete housekeeping pads under floor mounted electrical equipment.

B. Pads shall be constructed of 3,000 psi concrete.

C. Pads shall be 4 inches high, and 4 inches wider than the equipment in both directions.

D. Rubber mats shall be provided in front of switchboards, motor control centers and substations. The rubber mats shall be 36" wide and 8" longer than the overall length of the equipment.

3.13 SEISMIC REQUIREMENTS - Refer to Section 260548.

3.14 ELECTRIC TRACERS FOR FREEZE PROTECTION

A. Coordinate installation with Division 23 mechanical contractor.

B. Verify all cable lengths and quantities with mechanical piping layout and installation drawings.

C. Install tracer cable, temperature sensors, and all equipment per the manufacturer's instructions.

D. Cable affixing shall be per the manufacturer's recommendation and subject to the approval of the engineer. All epoxies, clips, and tie downs shall be suitable for temperatures from -40°F to 185°F.

E. Installation: All pipes to be traced are subject to field inspection with the manufacturer prior to release for manufacturing. Since field conditions may necessitate changes in cable arrangements, length, etc., Architect/Engineer shall be notified of the need for design changes which may result from field conditions.

1. Cables and controls shall be installed in accordance with manufacturers recommendations and current industry practice.
2. Apply the heater linearly on the pipe after piping has been successfully pressure tested. Secure the heater to pipe with fiberglass tape on 18" spacing.
3. Apply "Electric Traced" signs to outside of thermal insulation.
4. Installation shall comply with requirement of NEC and applicable portions of NECA's "Standard of Installation".

F. Field Quality Control: All heating cable shall be tested in accordance with manufacturer's recommendations prior to installation. Upon completion of the electrical installation, heater cable shall be tested again before thermal insulation is installed, and again after thermal insulation is installed to insure that heaters and controls are fully functional.

1. On receipt of material, after installation of heater on pipe, and before and after installing thermal insulation, subject heater cable to testing using a 1000 VDC megger. Minimum insulation resistance should be 20 to 1000 megohms regardless of heater length.

2. Startup and programming of heat trace controllers to be by manufacturer’s representative.

3.15 OCCUPANCY/VACANCY SENSORS

A. Upon completion of the installation, the system shall be adjusted by the manufacturer's factory authorized technician or the electrician who will verify all adjustments and sensor placement to ensure a trouble-free occupancy-based lighting control system.

B. Upon completion of the system adjustment the factory authorized technician shall provide the proper training to the owner's personnel in the adjustment and maintenance of the sensors.

END OF SECTION 26 05 00

SECTION 26 05 43

UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this Section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this Section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this Section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturer's product data and shop drawings for the following:

1. Manholes and Handholes Plans, Details, Sections and Elevations.
2. Installation Instructions and Recommendations for Manholes and Handholes.
3. Concrete and Rebar Design Data.
4. Cable Supports and Accessories.
5. Covers and Frames.
6. Transformer pad/vault.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide conduits, ducts, manholes, handholes, and accessories as indicated and specified, and as required for a complete underground raceway system.

B. Provide materials and equipment listed by UL when such equipment is available.

C. Conduit shall be rigid hot-dipped galvanized steel for sweeps and risers and plastic for runs, and as specified on drawings and conforming to the following:

1. Rigid Steel: Rigid galvanized steel conduit and fittings shall conform to the requirements of UL 6, ANSI C80-1 and NEC Article 346. Fittings and couplings shall be threaded.

2. Plastic duct for concrete encasement shall be Schedule 40 PVC and shall conform to NEMA TC2. Fittings shall conform to NEMA TC9.

3. Plastic duct for direct burial shall be Schedule 40 PVC and shall conform to NEMA TC2 and NEC Article 347.

D. Pull rope shall be synthetic and having a minimum tensile strength of 500 pounds.

E. Grounding and bonding equipment shall be in accordance with UL 467. Ground rods shall be copper clad steel, 3/4 inch in diameter and 10 feet long, unless otherwise indicated. Provide #4/0 bare copper secured to the four perimeter walls and bond metallic cable racks, ladders and accessories to the ground rod.

F. Provide a fiberglass ladder for each manhole entry.

2.02 MANHOLES & HANDHOLES (H-20/TRAFFIC RATED)

A. Manholes and handholes shall be precast reinforced concrete, manufactured by a firm with a minimum of five (5) years successful experience in such structures of similar sizes, designed in accordance with applicable AASHTO and ACI standards as certified by a registered professional structural engineer. Design and construction shall be suitable for the indicated locations and applications.

B. Manhole and handhole inside dimensions shall be minimum as follows and as shown on drawings, except that manufacturer's next larger standard sizes may be provided where site conditions allow. Provide duct bank windows coordinated with duct bank routing and to match ductbank pitch and drainage requirements.

1. Minimum handhole dimensions: 2’9”H x 3’2”W x 4’6”L
2. Minimum manhole dimensions: 7’0”H x 8’0”W x 8’0”L

C. Provide manhole roof with 38 inch diameter opening in center. Provide precast concrete neck or riser segments of suitable height (12 inches minimum) to coordinate ductbank to slope and drain away from building foundations, to match top of frame flush with finished grade and duct bank depth with entrance window. Provide 32 inch diameter cast steel frame and cover suitable for roadway installation, minimum H-20 vehicular traffic loading.

D. Handhole covers shall be vault style, galvanized steel, secured by bolts and sized to match full interior opening of handhole. Provide angle frame in bottom section or extension section of handhole to receive cover. Cover shall be suitable for roadway installation, minimum H-20 vehicular traffic loading. Provide inserts to lift cover. Provide precast concrete extension sections of suitable height (6 inches minimum) to coordinate ductbank to slope and drain away from building foundations and duct bank depth with entrance window. Include top section adjusting bolts to match top of frame flush with finished grade.

E. Provide manhole and handhole floors with 12 inch diameter sump hole in one corner, and 1 inch diameter ground rod hole in another corner.

F. Provide manhole walls with a recessed 3 inch diameter pull eye, made of 3/4 inch galvanized rebar, opposite each duct window. Provide handhole with recessed ¾ inch galvanized pulling iron center in floor. Provide threaded inserts as required for installation of indicated cable racks in manholes and handholes. Hardware shall be galvanized steel.

G. Provide non-metallic glass reinforced polymer cable racks minimum 120 lbs. capacity per arm on 48 inch centers with adjustable 10 inch arms, 3 arms per rack for manholes. For handholes provide racks centered on the walls with adjustable 6 inch arms and 2 arms per rack; Underground Devices, Inc. or approved equivalent.

2.03 HANDHOLES (NON-TRAFFIC BEARING)

A. Non-traffic bearing handholes shall be non-metallic polymer (Quazite or approved equal) of indicated minimum dimensions, with full-size covers.

B. Provide handholes with minimum 2 inch diameter drain hole in bottom.

2.04 IN-GROUND CAST BOXES

A. Provide vehicular traffic bearing cast polymer resin concrete or non-traffic bearing cast fiberglass underground junction and pull boxes for flush mounting as required by conditions and as shown on drawings.

1. Manufacturers: Polymer concrete - Quazite or Synertech; Cast fiberglass - PenCell; or approved equivalents.

2.05 TRANSFORMER VAULT/PAD

A. Provide precast or cast in place concrete transformer vault/pad for utility distribution transformer in accordance with utility specifications.

B. Precast transformer vault/pads shall meet Progress Energy – Carolinas Service Area, requirements, size: 76" x 70" x 36" deep, suitable for 500-2500 kVA transformers.

C. Provide minimum of two (2) ground rods and #4/0 bare tinned copper ground loop placed 12-inches below undisturbed earth and 12-inches from pad perimeter and bonded to the transformer per utility.

D. Conduit orientation: Facing the conduit opening on the top section of the pad, primary conduits shall be on the left side and secondary conduits shall be on the right side. Primary conduits shall have a 90-degree sweep up inside the pad.

E. Protection: Where subject to vehicular damage or required by utility, provide one 4-inch vertical steel pipe filled with concrete and located at each corner of the concrete pad or required by Utility. Minimum height above grade shall be 60-inches, minimum depth below grade shall be 40-inches. Deliver the transformer after protection is installed.

2.06 COVERS

A. Manhole and handhole covers shall be provided with two (2) pickholes, 180^{o} apart.

B. Manhole and handhole covers shall be cast with the lettering "ELECTRIC", "TELEPHONE" OR "CATV", as appropriate.

C. Non-metallic polymer or cast fiberglass handhole box covers and cast iron or aluminum in-ground box covers shall be non-skid with neoprene gasket and stainless steel cover screws. Cover legend: "ELECTRIC", "TELEPHONE", "CATV" and as shown on drawings.

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 Basic Materials.

3.02 UNDERGROUND INSTALLATION

A. Underground installation shall conform to National Electrical Code and National Electrical Safety Code.

B. Underground duct with concrete encasement shall be constructed of individual conduits encased in concrete. The concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 3 inches of concrete cover around ducts. Separate conduits by a minimum concrete thickness of 2 inches, except electric conduits shall be separated from low voltage or signal system conduits by a minimum concrete thickness of 6 inches if combined in the same envelope.

1. The top of the concrete envelope shall have a minimum burial depth no less than that permitted by NEC Article 300, Section 300.50, and shall have a maximum depth to the top of the ductbank of 30 inches below grade.

2. Duct banks shall have a continuous slope downward toward manholes and handholes and away from building foundations with a minimum pitch of 3 inches in 100 feet. Except at conduit risers, changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet; sweep bends may be composed of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with conduits of less than 3 inches in diameter, and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger.

3. Terminate conduits in end-bells where ducts enter manholes and handholes. Stagger the joints of the conduits by rows and layers to strengthen the duct bank. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in duct bank. Install spacers per manufacturer's instructions. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring.

4. Connect to existing concrete encasement, foundations and concrete structures using dowels. Connect to manhole and handhole walls using dowels.

5. Prior to installing cables in underground duct banks, and plugs and pullropes in empty ducts, ensure that each duct is clear after rodding with a mandrel and left clean and dry.

6. Conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weephole or screen to allow water drainage. Provide a pullrope having 3 feet of slack at each end of unused or empty conduits.

7. Where it is necessary to cut the tapered end on a piece of conduit at the site, the cut and/or taper shall be made with a special tool or a lathe, so that the new taper matches the taper of the particular conduit being used.

C. Concrete for electrical work shall conform to the requirements of Division 3.

D. Underground duct without concrete encasement shall be constructed of individual conduits and shall be direct buried in the earth upon a 6 inch deep sand or granular bed and cover. Direct-buried conduits shall have a minimum burial depth no less than that permitted by NEC Article 300, Section 300.50, and shall have a maximum depth to the top of the conduits of 36 inches below grade.

E. Provide detectable tape manufactured specifically for warning and identification of buried cable and conduit. See Specification Section 260500 for details. Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

F. Excavating, backfilling, and compacting shall be as specified in Division 2.

G. Set handholes and in-ground cast boxes on a bed of minimum 6 inch deep compacted granular fill. Set manholes on a bed of minimum 24 inch deep compacted granular fill. Installation and assembly shall be per manufacturer's instructions.

H. Set handhole access covers flush with finished grade.

I. Install grout, caulk, and/or sealant as required at construction joints and duct entries to make watertight.

J. Separately rack and train conductors of different systems to provide maximum separation. For example, rack and train normal and emergency conductors or different voltage conductors on opposite walls of manholes and handholes.

K. Fireproof cables in manholes, handholes and vaults using fireproofing tape in half-lapped wrapping. Extend fireproofing one inch into duct.

END OF SECTION 26 05 43

SECTION 26 05 48

ELECTRICAL VIBRATION & NOISE CONTROL

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Install electrical equipment in a manner that prevents transmission of objectionable vibration into the structure. This isolation includes, but is not limited to, resilient mounting of transformers, dimmer racks, conduit, UPS's, gas/diesel generators, inverters, motor starters, remote fluorescent fixture ballast cabinets, and variable frequency motor controllers. The vibration isolation manufacturer shall provide supervision to ensure proper application, installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation, the manufacturer shall make a final inspection and report. The Contractor shall submit this report to the Owner's Representative, in writing, certifying the proper performance of the installation.

1.02 SUBMITTALS

A. Submit NEMA sound power ratings for transformers, dimmer racks, UPS's, gas/diesel generators, motor starters, remote fluorescent fixture ballasts, and variable frequency motor controllers.

B. Submit shop drawings for conduit passing through isolated block-outs in structure.

C. Submit shop drawings for resilient penetration sleeve/seals field fabricated or prefabricated.

D. Submittals shall show required efficiency, designed deflection and outside diameter of springs, when pertinent, and installation guidelines.

E. Submit shop drawings for neoprene mounts clearly marked to show equipment tag and weight, mount type and size, actual isolator deflection and maximum rated load for every mount. Submittals based on static load are not acceptable.

F. Indicate materials and show designs and calculations signed and sealed by a professional engineer.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATIONS - GENERAL

A. Electrical equipment shall be mounted in accordance with the specifications below and with the specific requirements shown in the equipment schedules. The vibration isolation manufacturer shall provide supervision to ensure proper application, installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation, the manufacturer shall make a final inspection and report. The Contractor shall submit this report to the Architect, in writing, certifying the proper performance of the installation.

B. The isolation manufacturer shall supply unit isolators, complete rails, where required, and shall be responsible for the selection of vibration eliminators and shall guarantee to meet the requirements of this specification.

C. Vibration isolators shall be designed or treated for resistance to corrosion. Steel components shall be PVC coated, or phosphate primed and finish painted with rust resistant enamel. Nuts, bolts and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with metal etching primer and painted with rust resistant enamel. Isolators exposed to the weather shall have steel parts hot-dipped galvanized. Nuts, bolts and washers shall be cadmium plated. Spring components shall be cadmium plated and neoprene coated.

D. Vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.

E. Isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.

F. The ratio of lateral to vertical stiffness shall be not less than 0.9 nor greater than 1.5.

G. The theoretical vertical natural frequency for each support point based upon load per isolator and isolator stiffness shall not differ from the design objectives for the equipment as a whole by more than + 10%.

H. Neoprene mountings shall have a shore hardness of 40 to 65, after minimum aging of 20 days or corresponding oven-aging.

2.02 MOUNTINGS

A. Type A, Seismic, Floor Mount - horizontal and vertical rated in tension, compression and shear, consisting of bridge-bearing neoprene, ductile iron housing, top 'N' cap screw with washer, and minimum four bottom anchor holes. Mountings shall have a minimum static deflection of 0.5 inch. Include structural steel channel rails with leveling bolts for rigid connection to the equipment. Basis of design: Mason Industries Type BR and Type DNR rails or approved equal by Kinetics Noise Control, Amber Booth or Korfund.

B. Type B, Seismic, Spring Mount – restrained single or multiple spring mount consisting of welded corrosion-resistant steel restraint, 'CS' cap screw and adjustment bolt, and base anchor holes as required. Basis of design: Mason Industries Type SLR or approved equal by Ace Mountings Company or Amber Booth.

C. Type C, Seismic, Suspension Mount - horizontal and vertical rated in tension, compression and shear, consisting of bridge-bearing neoprene, steel housing, top 'CS' cap screw with washer, and minimum six bottom anchor holes. Mountings shall have a minimum static deflection of 0.5 inch. Include structural steel channel rails with leveling bolts for rigid connection to the equipment. Basis of design: Mason Industries Type RBA/RCA and Type DNR rails or approved equal by Kinetics Noise Control, Amber Booth or Korfund.

D. Type D, Seismic, Wall Mount – bridge neoprene and electro-galvanized steel sleeve and washer type isolator with seismic anchor stud. Basis of design: Mason Industries Type PB or approved equal by Kinetics Noise Control, Amber Booth or Korfund.

E. Flexible Connectors

1. Penetrations of sound-rated walls, floors, and ceilings in sound-critical spaces shall be specially sealed in accordance with the requirements as outlined on the drawings.

2. Provide isolation couplings with molded neoprene sleeve, bonding jumper and hot-dip galvanized finish ductile iron end fittings for rigid metal conduit and intermediate metal conduit; Appleton Type CF-1, OZ Gedney Type DX or approved equal.

2.03 ISOLATION SCHEDULE

EQUIPMENT TYPE	ISOLATION TYPE
Floor Mounted Transformers	A
Floor Mounted Dimming Panels	A
Floor Mounted Unit Power Conditioners	A
Floor Mounted UPS's & Inverters	A
Suspended Transformers	C
Diesel/Gas Generators	B
Wall Mounted Equipment *	D

* wall mounted equipment shall include dimmer panels, transformers, and all controls/control panels with transformers, contactors, relays, fans, and/or moving parts.

2.04 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field fabricated from a pipe or sheet metal section that is ½-inch to ¾-inch larger than the penetrating element in all directions around the element and shall form a sleeve through the construction penetrated. Refer to drawing detail. Prefabricated sleeves shall be submitted for review prior to installation.

2.05 OUTLET BOX PAD

A. Outlet box pads shall be field installed to acoustically isolate spaces. Refer to drawing details and manufacturer's instructions. Box pad manufacturer shall be Harry A. Lowry & Associates, Inc., Sun Valley, CA 818-768-4661 or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 Basic Materials and Methods.

3.02 INSTALLATION

A. Install vibration isolation devices and systems in accordance with the manufacturer's instructions.

B. Floor Mounted Equipment to include:

1. 4-inch thick concrete housekeeping pads over entire floor area of supported equipment.

2. Supporting vibration isolation devices and bases.

3. Keying with hairpins as required to be integral with the structural slab.

4. Incorporating approved seismic restraint anchor plates flush with the top of the housekeeping pad.

C. Concrete per specification Division 3 describing requirements.

D. Verify installed isolators and mounting systems permit equipment motion in all directions.

E. Adjust or provide additional resilient restraints to limit startup equipment lateral motion to 1/4-inch.

F. Prior to startup, clean out foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base or isolators.

G. No rigid connections between equipment and building structure shall be made that degrades the vibration isolation system herein specified.

H. Do not install any equipment, piping or conduit that makes rigid contact with the "building" unless permitted in this specification. "Building" includes, but is not limited to slabs, beams, columns, studs and walls. Use flexible conduit for connections to equipment vibration isolated with springs or neoprene (transformers, dimmers, pumps, fans, chillers, boilers, etc.). Flexible conduit shall be minimum of 25% greater length than the separation between the isolated equipment and the termination of rigid conduit. Install flexible conduit to be slack and not to exceed the manufacturer's minimum recommended bending radius. For conduit sizes greater than 2” diameter, use pre-manufactured flexible conduit connectors instead of flexible conduit.

I. Use flexible conduit or a flexible conduit connector at every location where conduit crosses a building expansion or isolation joint.

J. Resiliently mount to structure conduit connected to vibration isolated electrical equipment for a distance equal to 200 conduit diameters and for any additional extent indicated on the Drawings. Wrap conduit with 1” Armaflex prior to restraining with wall-mounted clamp.

K. Provide steel sleeve, grouted rigidly in place for conduit penetrations through walls, floors, and ceilings of mechanical equipment rooms, machine rooms, electrical equipment rooms and elevator equipment rooms. Make inside dimension of sleeve ½-inch to ¾-inch greater than outside dimension of penetrating item on all sides. The sleeve shall extend 1-inch beyond the penetrated construction on each side. The penetrating element shall pass through the sleeve without contacting the sleeve. Pack annular space to full depth of penetration with intumescent fire-rated sealant to form an airtight seal. Refer to Section 260000 and drawing details.

L. Coordinate work with other trades to avoid rigid contact with the "building". Inform other trades following, such as plastering, drywall, electrical or sheet metal, to avoid any contact that would reduce the vibration isolation.

M. Bring to the Owner's Representative's attention, prior to installation, any conflicts with other trades which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the contractor's expense.

N. Correct, at no additional cost, installations that are deemed defective in workmanship or material as a result of project completion inspection or subsequent inspections due to owner complaints within a period of one year following acceptance.

O. Position isolators:

1. Close to building structure.
2. Between building structure and supplementary steel if required.
3. Not to contact acoustic rated walls.

P. Suspend isolators from rigid and massive support points.

Q. Adjust isolators to eliminate contact of the isolated rod with the hanger rod box retainer or short circuiting of the spring.

R. Provide outlet box pads for electrical, telecommunications, fire alarm, security boxes and the like where indicated on the drawings.

1. There shall be a separation of 24" between centerlines of outlet boxes or receptacles set into opposite sides of the wall. Conduit connecting such boxes shall be flexible and shall provide 6" slack per 24" of run.

2. In a double wall, boxes in opposite sides of the wall shall be located 24" on center, minimum. Effectively, this means that boxes on the same side of the wall will be 48" apart if there is a box between them on the other side of the wall.

3. The boxes shall be treated to reduce sound transmission. Unused knock-out holes shall be plugged with knock-out caps or spot welded closed. The openings or cutouts in the walls to receive the boxes/receptacles shall be made no more than 1/4" oversize to allow a 1/8" gap all around. The flanges shall be perimeter sealed with acoustical caulking, prior to the boxes/receptacles being inserted.

4. Outlets installed in gypsum board only partitions (no CMU in construction) in noise critical spaces will require that the outlet be wrapped on five sides with an

acoustical pad. The pad is a polybutadiene-butyl material with a self-adhesive backing. Adhere pads to boxes before mounting box or attaching conduit according to manufacturer's instructions. Install plaster rings and tightly secure before completely wrapping pad around gypsum board face of box. Fill any remaining voids between gypsum board and box with non-hardening acoustical sealant.

S. General Equipment Isolation and Seismic Restraint:

1. Provide 2-inch operating clearance between concrete inertia bases and housekeeping pad and 1-inch clearance between equipment or structural bases and housekeeping pad.

2. Isolation mounting deflection (minimum) as specified or scheduled on manufacturer's certified drawings.

3. Position equipment, structural base and concrete bases on blocks or wedges at proper operating height.

4. Electrical conduit connections to isolated equipment shall be looped or installed with flexible conduit to allow free motion of isolated equipment.

5. Install equipment directly on isolation system. Support rails between the equipment and isolators should not be used.

6. Position corner or side seismic restraints with equipment operation for operating clearance and weld or bolt seismic restraint to seismic anchor plates in housekeeping pad.

3.03 SEISMIC REQUIREMENTS

A. Adequately anchor floor mounted equipment to floor slab or housekeeping pad to resist 0.5g (minimum) horizontal accelerations. Where necessary, also provide U-channel bracing to structural steel or slab above.

B. Wall mounted enclosures and equipment on stud partitions or non-reinforced block walls shall be mounted via two (2) slab-to-slab steel U-channels anchored to the wall every 24 inches O.C., and anchored to the floor and ceiling slabs.

C. Where possible, conduit, cable tray & raceway hangers shall be less than 12 inches long. Where hangers are 12 inches or more in length, and conduit size is 2-1/2 inches or more and for cable tray, provide longitudinal and transverse sway bracing. Seismic restraints spacing shall be in accordance with hanger spacing.

D. Provide sway bracing for those conduit runs containing emergency and critical power and lighting, fire alarm circuits, other life safety systems regardless of conduit size.

E. Recessed lighting fixtures shall be independently supported from the structure above unless the suspended ceiling is seismic-rated and the fixtures are provided with earthquake clips.

END OF SECTION 26 05 48

SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The OPR and BOD documentation are included by reference for information only.

C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.

B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:

C. In addition, provide the following:
1. Certificates of readiness
2. Certificates of completion of installation, prestart, and startup activities.

3. O&M manuals
4. Test reports

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. **Red-lined Drawings:**

1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. **Operation and Maintenance Data:**

1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
2. The CxA will review the O&M literature once for conformance to project requirements.
3. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the Contractor.

D. **Demonstration and Training:**

1. Contractor will provide demonstration and training as required by the specifications.
2. A complete training plan and schedule must be submitted by the Contractor to the CxA four weeks (4) prior to any training.
3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.

4. The CA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CA, Owner, and Architect.
5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
7. Review data in O&M Manuals.

E. **Systems manual requirements:**

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The GC shall include final approved versions of the following information for the Systems Manual:
   a. As-Built System Schematics
   b. Verified Record Drawings
   c. Test Results (not otherwise included in Cx Record)
   d. Periodic Maintenance Information for computer maintenance management system
   e. Recommendations for recalibration frequency of sensors and actuators
   f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
   g. Training Records, Information on training provided, attendees list, and any on-going training
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meetings.

C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

I. Assist the CxA in all verification and functional performance tests.

J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

N. Participate in, and schedule vendors and contractors to participate in the training sessions.

O. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Lighting control systems

P. The equipment supplier shall document the performance of his equipment.

Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

R. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

S. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

T. Refer to Division 01 Section "General Commissioning Requirements" for additional Contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.

B. **Electrical Instrumentation and Control System Testing:** Assist the CxA with preparation of testing plans.

C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. ***Automatic temperature controls integrated with the electrical systems***
2. ***Coordination and functionality with the Building Automation System/Building Management Controls System***
3. ***Lighting Controls***

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.11 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

B. **Electrical Contractor.** The electrical contractor shall have the following training responsibilities:

1. Provide the CA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
7. Training shall include:
    a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
    b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
    c. Discuss relevant health and safety issues and concerns.
    d. Discuss warranties and guarantees.
    e. Cover common troubleshooting problems and solutions.
    f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.

g. Discuss any peculiarities of equipment installation or operation.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance of all pieces of equipment.

9. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Owner's.

END OF SECTION 26 08 00

SECTION 260923

REMOTE LIGHTING CONTROL

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

B. See other Division 26 sections for requirements of dimming equipment and systems not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers may be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' technical product data for relays, sequencers, power supplies, switches, plates, and other lighting control devices and equipment.

B. Submit installation and wiring instructions for furnished devices.

C. Submit project-specific shop drawings for low voltage control systems showing riser diagrams, dimensioned cabinet arrangements, complete component wiring diagrams, and clearly differentiating factory and field wiring.

PART 2 - PRODUCTS

2.01 LIGHTING CONTACTORS

A. Lighting contactors shall be electrically-operated, mechanically-held, UL listed for both ballast and tungsten loads, up to 600 VAC.

B. Provide with ampere ratings and pole quantities as indicated.

C. Unless otherwise indicated or required, provide contactors with 120 VAC operating coils. Provide optional control modules and accessories as indicated, or as required for proper interface with specified control devices.

D. Unless otherwise indicated, provide lighting contactors in suitably sized indoor NEMA 1 enclosures.

E. The contactor short circuit rating shall equal or exceed the rated interrupting capacity of the upstream overcurrent protective devices, or else provide line-side current-limiting fuses, one per pole, to suit.

F. Multi-pole 30 ampere lighting contactors shall be ASCO 918 or Square D Class 8903, Type LX.

G. Contactors 30 amperes and larger, suitable for panelboard mounting where indicated shall be ASCO 920 or Square D Class 8903, Type S.

2.02 INDOOR PHOTOELECTRIC CONTROLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on drawings or approved equal by one of the following:

1. Watt Stopper.
2. Intermatic, Inc.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. TORK.

B. Ceiling-Mounted Photoelectric Switch [and Skylight Photoelectric Sensors]: Solid-state, light-level sensor unit, for ceiling mounting [and for mounting under skylight, facing up at skylight] with separate relay unit [mounted on luminaire], to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.

2. Relay Unit: Dry contacts rated for 20A ballast load at 120- and 277-V ac, for 13A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

3. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn-on and turn-off levels within that range.

4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.

5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.03 OUTDOOR PHOTOELECTRIC CONTROLS

A. Provide photoelectric control for dusk to dawn automatic switching of outdoor lighting.

B. Control shall have a swivel mounting, light level adjustment, and polycarbonate housing.

C. Switch rating shall be 2000 watts tungsten, 1800 volt-amps ballast, at 120 or 208-277 volts as required.

D. Photoelectric control shall be Tork 2100 series or approved equal.

2.04 SITE LIGHTING CONTROL PANELS

A. Provide a four zone lighting controller with photosensor input, NEMA 3 indoor/outdoor enclosure. Each zone shall be capable of independent user settable turn-ON and turn-OFF light level set points ranging from 1 to 100 foot-candles.

B. Controller shall provide 30 amp contacts for each zone as well as a 500 ma, 24 VDC output, multi-voltage: 24-277VAC, normally open & normally closed. Power consumption: 30 VA maximum. Include separate wiring compartments for power and auxiliary connections.

C. Controller shall have one digital input per channel for:

1. Remote contact closure which can be used to turn corresponding outputs ON/OFF outside the normal control time.

2. Remote timed override which can be accomplished for the corresponding outputs with the use of optional remote: Tork Model SSA200R-24 or approved equal.

3. Programmer shall be capable of accomplishing Windows based settings on a PC for easy duplication of Memory Modules or individualized programs for multiple locations. Provide Tork Model MMP or approved equal.

D. Controller shall be capable of local override ON or OFF to the next scheduled event using the keypad for each zone.

E. Each zone shall be capable of astronomic function, automatic daylights savings time, leap year adjustment, 365 holiday capability with 24 single dates and 4 seasons of unlimited duration.

F. Each zone shall have a 3-position slide switch allowing for user settings based on:

1. Time of day ON, Time of day, OFF.
2. Light level ON, Time of day, OFF.
3. Light level ON, Light level, OFF.

G. Controller shall be capable of 99 set points with separate scheduling for each day of the week.

H. Controller shall have back-up capability for 6 months minimum using a field replaceable lithium battery.

I. Manufacturer: Tork Model DLC400BP & Model EPC2 photosensor or approved equals.

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 INSTALLATION

A. Install and connect lighting controls, switches, and components in strict accordance with manufacturer's instructions and wiring diagrams.

B. Interface the low voltage control system with the building management/automation system (BMS) for automatic time control of the connected lighting. Coordinate requirements with Division 23.

C. Locate and adjust photoelectric controls for proper dusk to dawn operation of outdoor lights.

D. Perform initial programming of time switches. Coordinate requirements with the Owner.

E. Interface site emergency lighting controls with emergency power source automatic transfer switches to override timeclock “off” signal during loss of normal power.

3.03 TESTING AND DEMONSTRATION

A. After energizing, demonstrate the operation of lighting controls to the Architect and Owner. Make any corrections or minor modifications as directed.

END OF SECTION 26 09 23

SECTION 262212

COMPUTER-GRADE ISOLATION TRANSFORMERS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

B. See other Division 26 sections for requirements of general-purpose transformers, panelboards, and other electrical distribution equipment not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers may be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturer's technical product data and performance specifications for computer-grade isolation transformers and components, including the following information:

1. Ratings, including % impedance.
2. Enclosure type and dimensions.
3. Tap ratings and quantities.
4. UL, ANSI, and NEMA compliances.

5. Noise attenuation.
6. Transient voltage suppression system ratings.

B. Submit short circuit, arc flash and overcurrent protection coordination study as described in Section 260000. Study shall accompany equipment submittals. Failure to include the study with the equipment submittals will cause the equipment submittals to be rejected.

PART 2 - PRODUCTS

2.01 TRANSFORMER CONSTRUCTION

A. Provide ventilated dry-type computer-grade isolation transformers, 3 phase, delta primary, grounded wye secondary, U.L. listed and labeled, of the indicated ratings and voltages.

B. Transformers shall comply with NEMA standard TP1 for optimum energy efficiency at 35% load. Transformers shall be labeled for EPA Energy Star program. Provide 115°C rise transformers for all transformers indicated on the drawings, unless specifically otherwise noted. Efficiencies shall be tested in accord with NEMA TP2, in minimums as follows:

Single Phase	
kVA	Efficiency
15	97.7%
25	98.0%
37.5	98.2%
50	98.3%
75	98.5%
100	98.6%
167	98.7%
250	98.8%
333	98.9%

Three Phase	
kVA	Efficiency
15	97.0%
30	97.5%
45	97.7%
75	98.0%
112.5	98.2%
150	98.3%
225	98.5%
300	98.6%
500	98.7%
750	98.8%

C. Transformers specifically designated on the drawings shall be Class 155 insulation minimum per UL 1561 and shall be designed for a maximum winding temperature rise of 115°C at rated load in a 40°C ambient. 115°C transformers shall comply with NEMA standard TP-1 and shall be designed for low energy losses at loads greater than 50% of nameplate rating. 115°C rise transformers shall have a continuous emergency overload capability of 15%. Provide 115°C rise transformers unless otherwise noted on the drawings.

D. Isolation transformers shall be constructed with copper windings and minimum dual electrostatic (Faraday) shielding.

E. The transformers shall be constructed, listed, and labeled to supply non-linear loads with a K-factor of K-13 minimum, including a 200% secondary neutral.

F. Provide transformers with six 2-1/2 percent primary winding taps, two above and four below nominal voltage.

G. Enclosures shall be suitable for indoor locations, either floor or platform mounting.

H. Transformers shall be convection-cooled.

2.02 RATINGS

A. Common mode noise attenuation – 140 dB.

B. Transverse mode noise attenuation – 90 dB.

C. Output voltage harmonic distortion: 0.5% with linear load; 5.0% maximum for 2/3 switched mode power supply load.

D. Impedance - 3% minimum, 5.5% maximum.

E. Efficiency - 96%, minimum.

F. Audible sound, maximum at 5 feet:
1. 15-50 kVA – 45 dBA
2. 51-150 kVA – 50 dBA
3. 151-225 kVA – 55 dBA

G. Magnetic field strength – less than 0.1 gauss at 1.5 feet.

H. Operating ambient conditions - 0^{o}C to 40^{o}C, 0-95% RH (non-condensing).

2.03 TRANSIENT SUPPRESSION

A. Units shall be constructed in accordance with NEMA Standard LS 1, UL 1449 Second Edition and tested using the transient waveforms specified in ANSI/IEEE C62.41 in accordance with the procedures set forth in ANSI/IEEE C62.45.

B. Provide factory-installed input surge arresters of appropriate voltage rating, and having the following performance characteristics:

1. FOW sparkover - 3200 volts maximum.

2. Discharge voltage (8x20 microsecond waveform) - 2.2 KV maximum @ 1500 amperes.

C. Provide a factory-installed output transient suppression network of appropriate voltage rating, fused, with status indicating lights, and having the following performance characteristics:

1. Peak current handling - 40,000 amperes, minimum.

2. Energy absorption - 200 joules per phase, minimum.

2.04 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide computer-grade isolation transformers manufactured by one of the following:

1. Controlled Power – Series 600K
2. On-Line Power – Iso-Care Series
3. Harmonics Limited – TransMax Plus

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 INSTALLATION - TRANSFORMERS

A. Provide primary and secondary connections with 24" of flexible steel conduit to minimize vibration transmission to the building structure.

B. Bond grounded conductor to the transformer case, to the nearest available interior metal water piping, to nearest grounded building steel, and to other metal piping in accordance with requirements of NEC Article 250. Size conductors per NEC, but use no smaller than No. 4 AWG copper. Provide single-point ground per Section 260500 and as indicated on drawings.

C. Connect with secondary neutral conductors rated 200% of rated secondary amperes.

D. Adjust tap connections as necessary to achieve a no-load secondary voltage of 100-105% of nominal.

E. Provide vibration & noise control and seismic restraints. Refer to Section 260548.

END OF SECTION 26 22 12

SECTION 262413

SWITCHBOARDS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this Section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this Section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this Section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials and Section 262700 Electric Service.

B. See other Division 26 Sections for requirements of panelboards and other electrical distribution equipment not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' catalog data for switchboards and components, including construction details and device specifications.

B. Submittals: Provide dimensioned plans and elevations, including required clearances and service space, component and device lists, and a single-line diagram showing main- and branch-bus current ratings and short-time and short-circuit ratings of switchboard, major features and voltage rating. Include the following:

1. Enclosure type and dimensions with details.
2. Dimensioned floor plan and elevation views.
3. Utility company metering provisions with indication of approval by utility company.
4. One-line diagram showing main and feeder devices.
5. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
6. Bus configuration, lug sizes, materials and current ratings.
7. Short-circuit current rating of switchboard.
8. Details of utility, fire pump tap section and other auxiliary compartments, including top/bottom pullbox sections.
9. Installation instructions and requirements.
10. Description of meters, metering equipment and software.
11. Surge protection devices (SPD).
12. Accessories and options furnished.
13. Wiring Diagrams: Details of schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.

C. Submit short circuit, arc flash and overcurrent protection coordination study as described in Section 260000. Study shall accompany equipment submittals. Failure to include the study with the equipment submittals will cause the equipment submittals to be rejected.

PART 2 - PRODUCTS

2.01 SWITCHBOARDS

A. General Construction

1. Furnish and install a dead front, completely metal enclosed, self-supporting switchboard structure, independent of wall supports for equipment rated 1200 amperes and larger and as indicated on the drawings. Voltage and ampere ratings shall be as indicated on the drawings. Switchboards shall consist of the required number of vertical sections bolted together to form one rigid structure. The sides and rear shall be covered with removable screw-on plates. Edges of front cover panels shall be formed. Emergency switchboard circuit breakers shall be individually mounted in separate vertical switchboard sections. Enclosures shall be NEMA 1 indoor construction.

2. Equipment shall comply with the latest applicable standards of NEMA PB2, UL 891 and NEC 408. Where switchboards are used as service entrance equipment, they shall comply with NEC and UL requirements for service entrance, and a UL service entrance label shall be provided.

3. Small wiring, fuse blocks, and terminal blocks within the switchboard shall be furnished as required. Groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Fuse and terminal blocks shall be readily accessible behind front access doors or covers, insulated or isolated from power bus bars and terminations.

4. Switchboards shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the 4" high concrete housekeeping pads without the use of floor sills.

5. Furnish cable pull sections and top cable pull boxes as required, complete with cable tie down supports.

6. Switchboard components and cabling shall be front-accessible, and structures shall be rear-aligned, suitable for mounting against a wall, except that main device sections rated 2500 amperes or more shall be provided with side or rear access as recommended by the manufacturer.

7. Wiring terminals for switchboards rated less than 100,000 amperes short circuit current shall be pressure type lugs. Switchboards rated 100,000 amperes short circuit current and greater shall be provided with compression type lugs.

8. Units indicated as "Space" shall have necessary provisions including bus for future installation of a switch or breaker. Where the manufacturer's standard arrangements provide additional blank spaces, such spaces shall also have provisions for future devices.

B. Bussing

1. Bus bars shall be silver-plated copper with bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to UL and NEMA standards at rated ampacity. Provide full height vertical bus for distribution sections. Provide full capacity neutral bus in each switchboard. Include provisions for future bus extensions and additional switchboard sections.

2. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. Ground bus cross-sectional area shall be minimum 25% of the main bus.

3. Hardware used on bus bars shall be high-tensile strength and plated. Terminals shall be of the anti-turn solderless type suitable for copper or aluminum cable of sizes indicated, with 75^{o}C insulation. Provide necessary bus splice hardware for field installation at shipping splits.

C. Circuit Breakers

1. Where protective devices are indicated to be enclosed circuit breakers, provide manually-operated stationary mounting molded case circuit breakers up to and including 1200 ampere frame. Provide insulated case, fixed mounting circuit breakers above 1200 ampere unless otherwise indicated on the drawings. Circuit breakers shall be U.L. listed and labeled. See other Division 26 sections for panelboard and switchboard applications.

2. Provide 100% rated circuit breakers where indicated for application at 100% of the breaker's continuous current rating and UL 489 compliant. Circuit breaker shall be marked: 'Suitable for continuous operation at 100 percent of rating'.

3. Frame and trip ratings shall be as indicated. Circuit breakers 200A and larger shall have field-interchangeable trip units within frame size. Circuit breakers 400AF and larger shall have field-adjustable electronic trip units, with field-interchangeable rating plugs within frame size. For emergency and standby distribution, provide electronic trip units as necessary to achieve selective coordination in accordance with NEC Articles 700 and 701.

4. Electronic trip units shall include and display the following protective functions and features:

   a. Adjustable long-time pickup and delay.
   b. Adjustable short-time pickup and delay.
   c. Adjustable instantaneous pickup (up to 10X).
   d. Trip target for each function.
   e. Voltage on each phase.
   f. Instantaneous current on each phase.
   g. Kilowatt hours & kilowatt demand.
   h. Instantaneous kVA & kVA demand.
   i. Power factor.
   j. Harmonic distortion.
   k. Phase failure.
   l. Shunt trip where indicated.
   m. Adjustable ground-fault pickup and delay (up to 1200 amperes pickup & 1 sec delay maximum) where indicated.
   n. Ground fault where indicated.
   o. Arc-fault where indicated.

5. Where so indicated, provide circuit breakers with electric trip mechanisms, trip indication lights, trip test switches, and fused control power source. If required, provide a switchboard-mounted portable power pack for each

switchboard to power up the trip unit to set or adjust trip set points when the breaker is not powered up.

6. Provide circuit breakers with handle locking devices and padlocking hasps.

D. Short-Circuit Ratings

1. Switchboards and devices shall be fully rated for the short-circuit currents indicated, and shall be so labeled. Series rating of main and feeder devices will not be accepted.

E. Utility Compartments

1. Where applicable, provide suitable compartments complete with bus work and supports for the installation of utility company metering transformers. See Section 262700 Electric Service for additional information.

F. Fire Pump Tap Compartments

1. Where applicable, provide suitable fire pump tap compartment ahead of service entrance disconnect switch complete with bus work and supports for the installation of utility company fire pump metering transformers.

2.02 SPD – SURGE PROTECTION DEVICES

A. Provide surge suppression devices internally mounted where indicated on the drawings. Equipment shall be manufactured by a single manufacturer and listed to the following standards, certified by an independent third party National Regulatory Testing Laboratory (NRTL) so as to operate as a system when more than one device is installed:

1. UL 1449, 3rd Edition updates effective September 29, 2009 “Surge Protective Devices”.
2. UL 1283 “Electromagnetic Interference Filters”.
3. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
4. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
5. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
6. National Electrical Code: Article 285.
7. SPD shall be UL labeled with 20kA nominal rating (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.

B. SPD manufacturer shall have at least five (5) years experience in manufacturing surge protection devices and shall be ISO 9001 or 9002 certified.

C. SPD shall be factory installed. Surge protection devices shall be connected on the load side of utility metering compartment and shall comply with local utility requirements.

D. SPD shall provide Standard 7 Mode Protection paths for modes of protection as follows:

1. Wye systems: Normal mode suppression line-to-line, line-to-neutral, common mode suppression line-to-ground and neutral-to-ground.

2. Delta and impedance grounded wye systems: Line-to-line and line-to-ground.

E. Submittals shall include information describing each unit and as a minimum establish compliance with the following criteria:

1. UL listed and labeled as Type 1 intended for Type 1 or Type 2 applications as follows:

   a. Service entrance: 300 kA per phase and 200 kA short circuit current rating (SCCR).
   b. Distribution: 100 kA per phase and 200 kA short circuit current rating (SCCR).
   c. Branch: 100 kA per phase and 65 kA short circuit current rating (SCCR).

2. Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200 V	1200 V	1200 V	2000V	320V

3. Maximum Continuous Operating Voltage (MCOV):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277	15%	320V

4. Suppression components shall be heavy duty metal oxide varistors and shall be field replaceable module(s) (service entrance only).
5. Audible noise: 35db or less @ 3 feet from unit.

6. Response time less than or equal to ½ nanosecond.
7. UL 1283 listed EMI/RFI filter with noise attenuation: -50dB or greater at 100 kHz.
8. Fusing: 200 kA symmetrical fault current interrupting capacity @ 600V.
9. Phase and operational status indicator LED indicator lights for power and protection status.
10. Surge counter (service entrance only).
11. Integral circuit breaker or fused disconnect switch (service entrance only).
12. Dual set of Form C dry contacts for remote monitoring.
13. Audible alarm & alarm disable.

2.03 CUSTOMER METERING SYSTEM

A. Where indicated on the drawings, provide main, sub-main and feeder circuits with microprocessor-based digital power meters as herein specified. Analog meters are not acceptable.

B. Meters shall be completely factory-installed, wired, and calibrated, and shall include the necessary current transformers, and fused potential or control power transformers or bus taps, to provide the specified functions. Customer metering shall be connected on the load side of utility metering compartment and shall comply with local utility requirements.

C. Meters shall be mounted either with the associated breaker, or group-mounted in an adjacent vertical section of the switchboard, clearly labeled with the associated breaker I.D., subject to switchboard manufacturer's space and arrangement requirements.

D. Meters shall continuously monitor the following parameters, with keypad selection of the display:

1. Phase & neutral currents (each phase, up to 125% circuit amperes).
2. Phase-neutral & Phase-phase voltages.
3. VI unbalance.
4. KW and KVA demand (adjustable interval).
5. Demand: Amperes, KW and KVA.
6. KWH.
7. Hz: Watts, VAR, VA.
8. Watt-hour, VAR-hour, Watt cost.
9. Power factor.
10. Harmonic analysis through 63rd with THD and TIF.
11. Waveform capture.
12. Data logger: 98,000 events minimum.
13. Voltage disturbance recorder (VDR) – 500 events minimum.

E. Meters shall be auto-ranging for each parameter. Displayed values shall be actual values, requiring no multiplying factors; minimum 0.2% accuracy.

F. Each meter shall contain integral RS-485 and RS-232 serial data communications ports with ModBus and DNP 3.0 protocol for linking to a remote energy-monitor PC. Include Ethernet connectivity via Multinet or approved equal communications module. Communications and monitoring software package shall be provided by the meter manufacturer, shall be Windows (TM) based, and shall be able to continuously monitor data from up to 128 compatible devices. The data link shall be connected to, and the software loaded into, the BMS computer specified under another Division. Coordinate requirements between manufacturers.

G. Metering, software and accessories shall be Eaton Cutler-Hammer IQ 260, General Electric Multilin Power Quality Meter PQM II, Square D PowerLogic ION7550 or approved equal by Power Measurement Limited.

2.04 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide switchboards and components manufactured by one of the following:

1. Siemens Industry Inc.
2. Eaton Cutler-Hammer
3. Square D Company
4. General Electric Company

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260000 General Provisions and Section 260500 Basic Materials and Section 262700 Electric Service.

3.02 INSTALLATION

A. Install and assemble switchboards and components in strict accordance with manufacturer's instructions.

B. Field coordinate exact locations for bottom entry conduits, where applicable.

C. Drawings show schematic locations for switchboards with the contractor responsible for final field installation to Code standards and working clearances.

D. Clearly label the exterior of each switchboard with I.D. number from drawings, system voltage, and ampere rating of bussing and main protective device / MLO, and rating/Class of fuses on engraved nameplates.

E. Install RS-485 metering cabling adjacent to BMS cabling. Interconnect with the metering of other switchboards per manufacturer's instructions.

F. Surge protection remote alarm: Provide for remote alarm monitoring connections. Provide raceway and 3#14 AWG conductors from surge protection device dry contacts to a junction box located adjacent to the switchboard including empty conduit from junction box to BMS. Final connection of SPD alarm contacts is provided under Division 23 and shall not require access to switchboard or de-energizing of switchboard.

G. Provide configuration and in-service testing of the Customer Metering System/EPMS by a factory authorized service representative for complete verification of the system. Include Owner’s personnel training consisting of programming, startup, shutdown, troubleshooting, servicing and preventive maintenance of metering system.

3.03 FIELD ACCEPTANCE TESTING

A. After switchboard installation and assembly, but prior to energizing, the contractor shall provide the services of factory-authorized field service technicians to inspect each assembly, perform factory-recommended tests and adjustments, and to calibrate and set solid-state trip units and digital meters to suit project requirements.

B. A signed field service report for each unit shall be submitted for record.

C. Coordinate metering software loading, setup, checkout, and demonstration with the BMS package. Verify correct performance.

D. Adjust fuse and circuit breaker trip settings in accordance with the approved coordination study and equipment manufacturer's recommendations.

E. Document and label the flash protection boundary and the incident energy in accordance with IEEE 1584, NEC and the approved short circuit, arc flash and overcurrent protection coordination study.

END OF SECTION 26 24 13

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

B. See other 26 sections for requirements of switchboards and other electrical distribution equipment not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The design is based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' catalog data for panelboards, including enclosure details and device specifications.

B. Submittals: Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:

1. Enclosure type and dimensions with details.
2. Bus configuration, lug sizes, materials and current ratings.
3. Short-circuit current rating of panelboard.

4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
5. Accessories and options furnished.
6. Wiring Diagrams: Details of schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.

C. Submit short circuit, arc flash and overcurrent protection coordination study as described in Section 260000. Study shall accompany equipment submittals. Failure to include the study with the equipment submittals will cause the equipment submittals to be rejected.

PART 2 - PRODUCTS

2.01 PANELBOARDS

A. General

1. Furnish and install approved panelboards of types and configurations indicated and specified herein.

2. Panelboards shall comply with the following industry standards:

   a. UL Standards
      (1) Panelboards - UL67
      (2) Cabinet & Boxes - UL50
      (3) Circuit Breakers - UL489
      (4) Fused Switches - NEMA KS 1
   b. National Electric Code Article 408
   c. NEMA Standard - PB 1

3. Panels identified for use as service entrance equipment shall be so labeled and equipped.

B. Interiors

1. Interiors shall be completely factory assembled. They shall be so designed that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors, so that circuits may be changed without machining, drilling or tapping.

2. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated.

3. A manufacturer's nameplate shall be provided listing panel type and ratings.

4. Bus bar taps for panels with single pole branches shall be arranged for sequenced phasing of the branch circuit devices.

5. A copper ground bus shall be included in panels. An isolated ground bus shall be provided in panels as indicated on Contract drawings.

6. Where "SPACE" is indicated on the schedules, it shall be fully equipped for future installation of the indicated device, with a blank cover over live parts.

C. Boxes

1. Boxes shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with standards. 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. Provide gutter barriers for panels requiring through-feed gutters.

2. At least four interior mounting studs with adjustable nuts shall be provided.

D. Trim

1. Switching device handles shall be accessible without exposure to any live parts. Doors shall have flush type cylinder lock and catch, except doors over 48 inches in height shall have auxiliary fasteners top and bottom of door in addition to the flush type cylinder lock and catch.

2. Door hinges shall be concealed. Locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished with each door.

3. Exterior and interior steel surfaces of the trim shall be properly cleaned, primed with a rust inhibiting phosphatized coating, and finished with a gray ANSI 61 paint. Trims for flush panels shall overlap the box for at least 3/4 inch all around. Surface trims shall have the same width and height as the box.

4. Front trim shall be hinged "door within a door" construction consisting of an inner door, outer door and an outer frame. Inner door shall allow access to circuit breakers and the outer door shall allow access to circuit

breaker terminations, wiring and gutter space without having to remove trim. Provide key operated latch(s) on each door with multiple latches as required by size of doors. The outer frame shall be secured to the enclosure box with course thread slotted machine screws. Toggles, clamps and cam-operated fasteners are not acceptable. Provide a centered, top mounted stud secured to the enclosure box to facilitate outer frame removal and installation.

E. Bus Bars and Connectors

1. Main bus bars and branch connectors shall be tin-plated copper, sized in accordance with UL standards to limit the temperature rise on any current carrying part.

2. Circuit breaker panelboards shall utilize bolt-on breaker connections.

3. Provide full capacity insulated neutral bus in each panelboard. Neutral bussing shall have a suitable lug for each outgoing circuit requiring a neutral connection.

4. Provide sub-feed, feed-through and through-feed lugs as shown on drawings.

F. Circuit breakers shall be thermal-magnetic molded case type. See Section 260500 and as follows:

1. One and two pole circuit breakers for lighting circuits shall be labeled for switching duty (SWD) and (HID), if used for switching high intensity discharge lighting.

2. Circuit breakers shall be full-size type: Half-size, twin or tandem breakers are not acceptable.

3. Circuit breakers feeding exit lights and emergency lighting shall be provided with handle locking devices. Where so indicated, provide circuit breakers with padlocking devices.

G. Short-Circuit Ratings

1. Panelboards and devices shall be fully rated for the short-circuit currents indicated, and shall be so labeled. Series rating of main and branch devices will not be accepted.

H. Panelboard circuit configurations and voltage, ampere, and short- circuit ratings shall be in accordance with the schedules on the drawings.

I. Panelboards shall be commercial or industrial grade. Residential grade load centers will not be accepted.

J. Lighting and appliance panelboards and power distribution panelboards up to and including 400 amperes shall be equivalent of Square D NQOD or NF series, Eaton Cutler-Hammer Pow-R-Line 2 series or GE A series.

K. Power distribution panelboards rated above 400 amperes shall be equivalent of Square D I-line type HCN, HCM, HCW, HCNM or HCWM-U, Eaton Cutler-Hammer Pow-R-Line 4 series or GE Spectra series.

2.02 SPD – SURGE PROTECTION DEVICES

A. Provide surge suppression devices internally mounted where indicated on the drawings. Equipment shall be manufactured by a single manufacturer and listed to the following standards, certified by an independent third party National Regulatory Testing Laboratory (NRTL) so as to operate as a system when more than one device is installed:

1. UL 1449, 3rd Edition updates effective September 29, 2009 “Surge Protective Devices”.
2. UL 1283 “Electromagnetic Interference Filters”.
3. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
4. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
5. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
6. National Electrical Code: Article 285.
7. SPD shall be UL labeled with 20kA nominal rating (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.

B. SPD manufacturer shall have at least five (5) years experience in manufacturing surge protection devices and shall be ISO 9001 or 9002 certified.

C. SPD shall be factory installed. Surge protection devices shall be connected on the load side of utility metering compartment and shall comply with local utility requirements.

D. SPD shall provide Standard 7 Mode Protection paths for modes of protection as follows:

1. Wye systems: Normal mode suppression line-to-line, line-to-neutral, common mode suppression line-to-ground and neutral-to-ground.

2. Delta and impedance grounded wye systems: Line-to-line and line-to-ground.

E. Submittals shall include information describing each unit and as a minimum establish compliance with the following criteria:

1. UL listed and labeled as Type 1 intended for Type 1 or Type 2 applications as follows:

   a. Service entrance: 300 kA per phase and 200 kA short circuit current rating (SCCR).
   b. Distribution: 100 kA per phase and 200 kA short circuit current rating (SCCR).
   c. Branch: 100 kA per phase and 65 kA short circuit current rating (SCCR).

2. Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

3. Maximum Continuous Operating Voltage (MCOV):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277	15%	320V

4. Suppression components shall be heavy duty metal oxide varistors and shall be field replaceable module(s) (service entrance only).
5. Audible noise: 35db or less @ 3 feet from unit.
6. Response time less than or equal to ½ nanosecond.
7. UL 1283 listed EMI/RFI filter with noise attenuation: -50dB or greater at 100 kHz.
8. Fusing: 200 kA symmetrical fault current interrupting capacity @ 600V.
9. Phase and operational status indicator LED indicator lights for power and protection status.
10. Surge counter (service entrance only).
11. Integral circuit breaker or fused disconnect switch (service entrance only).
12. Dual set of Form C dry contacts for remote monitoring.
13. Audible alarm & alarm disable.

2.03 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide panelboards manufactured by one of the following:

1. Siemens Industry Inc.
2. General Electric Company
3. Square D Company
4. Eaton Cutler-Hammer

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 INSTALLATION - PANELBOARDS

A. Drawings show schematic locations for panelboards with the contractor responsible for final field installation to Code standards and working clearances.

B. Unless otherwise indicated, mount panelboards with top of enclosure 6'-6" above finished floor. Mount securely, per manufacturer's instructions, with top and sides level and plumb.

C. Surface-mounted panelboards shall be mounted on ¾-inch plywood backboard or ¾-inch galvanized steel channel secured to wall. Do not use plywood backboard in wet or damp locations. Where required provide galvanized steel channel to stand panelboards six inches off wall to allow routing conduit or cable behind panelboards.

D. Provide typewritten as-built circuit directory information for each panelboard, including load description and location. Circuit description shall conform to NEC Paragraph 408.4, which states “identification shall include sufficient detail to allow each circuit to be distinguished from all others.”

E. Clearly label the exterior of each panelboard with I.D. number from drawings, system voltage, and ampere rating of panel bussing and main protective device/MLO, and rating/Class of fuses on engraved nameplates.

F. For flush-mounted panelboards, provide 3-1" EMT sleeves to ceiling cavity above and below (3 conduits up, 3 conduits down), capped, for future additional branch circuit wiring.

G. Install required interconnecting conduit and wiring for multi-section panelboards.

H. Provide insulated gutter tap assemblies with insulating cover; Burndy Type KPU-AC Polytap or Type UCU-AC Riser Tap or equal by O.Z. Gedney. Split-bolt and taped tap connections are not acceptable.

I. Document and label the flash protection boundary and the incident energy in accordance with IEEE 1584, NEC and the approved short circuit, arc flash and overcurrent protection coordination study.

J. Surge protection remote alarm: Provide for remote alarm monitoring connections. Provide raceway and 3#14 AWG conductors from surge protection device dry contacts to a junction box located adjacent to the switchboard including empty conduit from junction box to BMS. Final connection of SPD alarm contacts is provided under Division 23 and shall not require access to panelboard or de-energizing of panelboard.

END OF SECTION 26 24 16

SECTION 26 27 00

ELECTRIC SERVICE

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions and section 260500 Basic Materials.

B. See other Division 26 sections for requirements of electric service distribution equipment not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation are based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' catalog data for the following service equipment:

1. Meter sockets.

B. Submit shop drawings for the following fabricated service equipment:

1. CT/PT cabinets, including bus work and mounting hardware.

1.05 UTILITY FEES

A. Provide work, materials, and fees required and/or charged by Progress Energy relating to the establishment of electric service for the project.

PART 2 - PRODUCTS

2.01 METER SOCKETS

A. Provide meter sockets, which comply with requirements of the local utility company.

2.02 CT/PT CABINETS

A. Provide CT/PT cabinets, and mounting hardware, which comply with requirements of the local utility company. Unless otherwise indicated, CT's and PT's for revenue metering will be furnished by the utility company.

B. Where so indicated, CT/PT cabinets shall be an integral component of the electric service distribution equipment.

2.03 TRANSFORMER VAULT/PAD – Refer to Section 260543

2.04 MISCELLANEOUS MATERIALS

A. Provide painted plywood backboard, conduit, wire, and any other miscellaneous materials and hardware required by the utility company.

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 COORDINATION WITH ELECTRIC UTILITY COMPANY

A. Consult with the electric utility company for verification of scope of work to be performed. Perform work pertaining to the electric service in strict accordance with utility company standards and requirements. Verify service voltage, phasing, and connections. In event of conflict between design and/or scope of service, notify Architect in writing.

3.03 INSTALLATION OF SERVICE-ENTRANCE EQUIPMENT

A. Where applicable, receive utility company equipment at the property line, transport to indicated installation location, install and connect per utility company instructions.

B. Identify service disconnecting means per NEC 230-70(b) and 230-77.

C. Bond and ground service entrance equipment in accordance with codes, utility company requirements, as indicated, and as specified in another Division 26 section.

3.04 FINAL INSPECTION

A. Upon completion of installation and testing of service-entrance equipment and electrical circuitry, arrange for final inspection by the utility company and local authorities, energize circuitry, and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

END OF SECTION 26 27 00

SECTION 26 32 00

EMERGENCY POWER SYSTEM

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this Section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

B. See other Division 26 Sections for requirements of emergency system panelboards and other electrical distribution equipment not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The criteria of design and performance to produce the required operation is based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' project-specific technical data for emergency power system equipment and components, including construction details, engine and alternator performance specifications, and mounting and installation instructions.

B. Submit project-specific shop drawings including the following:

1. Factory dimensioned layout and arrangement drawings. Typical catalog cuts are not acceptable.

2. Complete wiring diagrams for system components.

3. Complete rigging diagrams and assembly procedures for the generator and generator enclosure

C. Submit a listing and report of factory tests performed.

D. Submit certified field test report upon completion of work.

E. Submit complete operating and maintenance manual.

F. Submittals shall be tabbed and indexed for easy reference and location of submitted components (i.e. generator, radiator, silencer, fuel system, enclosure, etc.).

G. Submit short circuit, arc flash and overcurrent protection coordination study as described in Section 260000. Study shall accompany equipment submittals. Failure to include the study with the equipment submittals will cause the equipment submittals to be rejected.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide a complete integrated emergency power system including, but not limited to, engine-generator set(s), automatic transfer switch(es), fuel system, exhaust system, sound-attenuated weather protected enclosure, remote annunciation, and power distribution, as indicated and herein specified. The system shall provide specified voltage, power and frequency to the designated circuits and loads within 10 seconds of loss of utility power.

B. The emergency power system shall be in compliance with the following codes and standards:

1. NEC Compliance: Comply with applicable requirements of NEC Articles 700 (Emergency Systems) pertaining to emergency systems.

2. NFPA Compliance: Comply with applicable requirements of NFPA 37, "Stationary Combustion Engines and Gas Turbines", and NFPA 110 "Emergency and Standby Power Systems" (Level 1).

3. UL Compliance: Provide standby power generator system and enclosure components that are listed and labeled to UL 2200 standard.

4. ANSI/NEMA Compliance: Comply with applicable requirements of ANSI/NEMA MG 1 "Motors and Generators", and MG 2 "Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators".

C. The system manufacturer shall have a factory-authorized parts and service facility within a reasonable distance of the jobsite.

2.02 ENGINE-GENERATOR SET

A. The engine-generator set shall be nominally rated as indicated on the drawings. The kW rating shall be at 0.8 power factor, 122°F/50°C ambient air temperature, for standby operation for the duration of any utility power outage. Motor-starting capability shall be minimum 600 kVA at 90% sustained voltage with a maximum 15% voltage dip. The manufacturer shall provide oversized components as may be necessary to meet this requirement.

B. Engine

1. The engine shall be an 1800 rpm water-cooled compression ignition diesel. Engine shall meet specifications when operating on No. 2 (Grade DF-2) domestic burner oil. Diesel engines requiring premium fuels will not be considered. The engine shall be equipped with fuel, lube oil, and intake air filters, lube oil coolers, fuel transfer pump, fuel priming pump, and gear driven water pump. The engine shall be Cummins Model DSGAE. The engine shall be configured for low exhaust emissions and comply with Tier 3 EPA guidelines.

2. The engine governor shall be isochronous electronic type and shall maintain frequency regulation not to exceed 0.25% (0.15 Hertz) from no load to full rated load.

3. The unit shall be mounted on a structural steel sub-base and shall be provided with adjustable spring-type seismic-rated vibration isolators. Provide anchor bolts of hot dipped galvanized steel, of the types and sizes recommended by the manufacturer.

4. Provide safety shut-offs for high water temperature, low water level, low oil pressure, overspeed and engine overcrank.

5. Provide a thermostat-controlled thermal circulation type jacket water heater to maintain engine jacket water at 90°F in an ambient temperature of 0°F.

6. Provide a crankcase emission control system that shall remove a minimum of 99% of crankcase emissions including NOX, hydrocarbon and oil.

7. An engine-mounted radiator with blower type fan shall be sized to maintain rated operation at 122^{o}F/ 50^{o}C maximum outside air temperature. The radiator shall be stacked core design. The aftercooler circuit shall be rated at 140^{o}F. The engine cooling system shall be filled with an anti-freeze solution of 50/50 ethylene glycol/ water mixture. Rotating parts shall be guarded against accidental contact per OSHA requirements.

C. Starting System

1. Provide engine-generator unit with a 12 or 24 volt (manufacturer's standard) DC electric starting motor with positive engagement drive capable of three complete cranking cycles without overheating.

2. Provide a non-gassing lead calcium recombination type engine starting battery set of the heavy-duty diesel type to avoid requirements for ventilation. The battery set shall be of sufficient capacity to provide for one and one half minutes total cranking time without recharging. Include a corrosion-resistant battery rack, and necessary cables and clamps.

3. Engine mounted battery charging alternator shall be 45 ampere minimum with solid-state voltage regulator.

4. Provide a current limiting battery charger located at the generator to automatically recharge batteries and to maintain at full charge. Charger shall float at 2.20 volts per cell and equalize at 2.40 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC voltmeter, DC ammeter, and fused AC input. AC input voltage shall be 120 volts. Amperage output shall be no less than 10 amperes. Provide Stored Energy Systems Model NRG or approved equal.

D. Exhaust System

1. Provide an internally mounted critical grade exhaust silencer including rain cap along with appropriately sized piping to the engine exhaust manifold. Final connection to the manifold shall be flexible stainless steel for vibration isolation. The silencer and piping shall be of high temperature and corrosion-resistant (aluminized shell & heads) construction. Manufacturer: GT Exhaust Systems, Inc.; Model 201-7100 Extreme Application series or approved equal.

2. For interior installations, exhaust pipe extensions beyond the silencer will be furnished and installed under Division 23. Where no such extensions are required, provide a suitably configured exhaust outlet and, where required, a rain cap.

E. Generator (Alternator)

1. The generator shall be a three-phase, wye-connected, grounded neutral, 60 Hertz, single bearing, four pole, synchronous type, 105°C temperature rise at 200 kW / 250 kVA standby output, 208Y/120 volts with brushless exciter and shall be built to NEMA Standards. 125°C or 150°C temperature rise is not acceptable. Shunt excitation is not acceptable. Class H insulation shall be used on the stator and rotor, and both shall be further protected with 100% epoxy dipped and baked impregnation. Stator shall be skewed with 2/3 pitch windings to minimize field heating and voltage harmonic effects. Generator shall be Onan Frame Size: UCD3J or approved equal.

2. A generator mounted solid-state voltage regulator shall be provided to match the characteristics of the generator and engine. Voltage regulation shall be +/- 2% from no load to full rated load. Readily accessible voltage droop, voltage level and voltage gain controls shall be provided. Voltage level adjustment shall be a minimum of +/- 5%. One-step application of 100% rated load shall result in a voltage drop of no greater than 15% of rated, and recovery to steady-state shall be within 5 seconds. Generator output voltage distortion shall be less than 5% total harmonic distortion (THD) line-to-line and line-to-neutral when supplying full rated linear load with no greater than 3% individual harmonic content. To limit voltage distortion for non-linear load current harmonics, the generator per unit sub-transient reactance shall not exceed [0.11] at generator temperature rise rating under full load.

   a. The manufacturer shall review the generator application, and the indicated loads served, to determine what level of filtering or derating, if any, is recommended or required for satisfactory regulator and generator performance. Provide equipment accordingly.

   b. Provide alternator anti-condensation heater, thermostatically controlled, 120 volt.

3. Connection to the engine flywheel shall be via a semi-flexible disc coupling.

4. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for more than 10 seconds.

5. Provide unit mounted, three-pole, molded-case circuit breakers for life safety, fire pump, and stand-by loads at the generator output terminals in NEMA 1 enclosure(s) to protect the generator and the generator supply conductors against overload as indicated on the drawings. Each circuit breaker shall have a trip rating as indicated on the drawings. The circuit breaker for fire pump emergency operation shall include (2) two Form C contacts to signal the fire alarm control panel and prevent generator startup if the circuit breaker is open per NFPA 20 and 70.

6. [In lieu of unit mounted circuit breakers at the generator output terminals, provide service entrance rated disconnect switch(es) as indicated on the drawings with overcurrent protection properly sized and set to provide overload protection for the generator and fire pump supply conductors. Each switch shall have a fuse [trip] rating as indicated. The disconnect switch [circuit breaker] for fire pump emergency operation shall include (2) two Form C contacts to signal the fire alarm control panel and prevent generator startup if the switch [circuit breaker] is open per NFPA 20 and 70.]

7. Provide (2) sets of ear protection to reduce noise levels to 20 db for the person wearing the headsets. Provide rack to hang heads sets by entry door.

F. Engine-Generator Set Control:

1. The generator set shall be provided with a microprocessor-based control system, which is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

2. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of components in the system under the vibration conditions encountered.

3. The control shall be UL508 labeled, CSA282-M1989 certified, and meet IEC8528 part 4. Switches, lamps and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. The controls shall meet or exceed the requirements of Mil-Std

461C part 9, and IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions. The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance.

4. The generator set mounted control shall include the following features and functions:

   a. Three position control switch labeled RUN/OFF/AUTO: In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

   b. Red "mushroom-head" push-button EMERGENCY STOP switch: Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

   c. Push-button RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

   d. Push-button PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

   e. Generator Set AC Output Metering: The generator set shall be provided with digital and analog metering set including the following features and functions:

      (1) 2.5-inch, 90 degree scale analog voltmeter, ammeter, frequency meter, and kilowatt (kW) meter. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters. Ammeter and kW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.

(2) Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output kW, kW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display three phase voltages (line to neutral or line to line) simultaneously.

f. Generator Set Alarm and Status Message Display: The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel (in addition, provide items designated (*) to signal at remote annunciator):

pre-low oil pressure (alarm)*
low oil pressure (shutdown) *
oil pressure sender failure (alarm)
low coolant temperature (alarm)*
pre-high coolant temperature (alarm)*
high coolant temperature (shutdown)*
engine temperature sender failure (alarm)
low coolant level (alarm or shutdown--selectable)*
fail to crank (shutdown)
overcrank (shutdown) *
overspeed (shutdown) *
low DC (battery) voltage (alarm)*
high DC (battery) voltage (alarm)*
normal DC (battery) voltage*
weak battery (alarm)*
battery charger malfunction*
low fuel-daytank (alarm or shutdown--selectable)*
high AC voltage (shutdown)
low AC voltage (shutdown)
under frequency (shutdown)
over current (warning)
over current (shutdown)
short circuit (shutdown)
over load (alarm)
emergency stop (shutdown)
generator running*
normal utility power*
EPS supplying load*
Not in auto*

g. In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

h. Engine Status Monitoring: The following information shall be available from a digital status panel on the generator set control:
engine oil pressure (psi or kPA)
engine coolant temperature (degrees F or C; Both left and right bank temperature shall be indicated on V-block engines.)
engine oil temperature (degrees F or C)
engine speed (rpm)
number of hours of operation (hours)
number of start attempts
battery voltage (DC volts)

i. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

j. Control Functions: The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

k. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

l. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

m. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.

n. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

o. Alternator Control Functions: The generator set shall include an automatic voltage regulation system that is matched and prototype tested with the governing system provided. It shall be immune from mis-operation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58-59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alpha-numeric LED readout to indicate setting level. The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

p. Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator.

q. Controls shall be provided to monitor the kW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

r. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

s. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

t. Provide a battery monitoring system to load test the batteries each time the engine is started. Test failure shall alarm when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.

u. Control Interfaces for Remote Monitoring - Control and interconnection points from the generator set to remote components shall be brought to a separate connection box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

(1) Form "C" dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.

(2) One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

(3) A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

(4) A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit continuously from the engine starting/control batteries.

(5) The control shall be provided with a direct serial communication link using LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.

G. Remote Annunciator

1. Provide a remote alarm annunciator, (18) light minimum (refer to 2.02-F-4-f), in a surface-mounted NEMA 1 enclosure containing indicating lights/LED’s for low oil pressure, high water temperature, overspeed, overcrank, low battery, low fuel level, fuel tank leak, other indications for NFPA 110, Table 3-5.5.2 (d) Level 1 (refer to generator control panel requirements), and an alarm horn with silencing pushbutton and light.

2. Remote annunciator shall be powered by the genset storage battery.

3. The remote annunciator shall have provisions to signal a common emergency power system alarm to the building security system. (See other Division 26 section for security system requirements).

4. The remote annunciator located at the Fire Command Center shall have provisions for the manual start, transfer and transfer override features required by Code. Provide required wire and conduit between genset and remote annunciator.

H. Shutdown Switch

1. Provide a breakglass-type remote manual shutdown switch per NFPA 110, 5.6.5.6. Switch shall be located [as shown on drawings] [outside the room enclosing the generator adjacent to entry door] [externally mounted to the outdoor generator enclosure; weatherproof type].

I. Sound Attenuated Weather Protected Enclosure

1. Provide corrosion-resistant sound attenuated weather protected enclosure for engine-generator set made of heavy gauge reinforced steel. Enclosure shall be sized for the engine-generator set and local auxiliaries (batteries, charger, day tank/sub-base tank, and as specified and indicated). The enclosure shall be provided with necessary louvers, louver operators, maintenance access doors and heaters. Enclosures shall be Cummins Quiet Site Stage II or approved equal with measured sound pressure level performance as follows: average - [70.6] dBA, maximum-[72.2] dBA measured at 7 meters.

J. Acceptable Generator Manufacturers

1. Subject to compliance with requirements, provide Cummins/Onan diesel engine-generator set Model DSGAE Series (Contact: Cummins Power Systems, Mr. Mike Rutty, T: 860-529-7474, michael.w.rutty@cummins.com or approved equal as manufactured by one of the following:

a. Caterpillar

2.03 FUEL SYSTEM & SUB-BASE TANK

A. Provide UL 142 listed sub-base tank and packaged fuel transfer system, size as hereinafter specified, complete with required connections and hardware.

B. The tank and all associated components shall be suitable for the application. Tanks with limitations on lengths of fill and/or vent piping shall not be permitted. Tanks shall have pressure ratings to comply with Code and local laws.

C. The tank shall be constructed of heavy gauge steel, have a removable gasketed inspection plate 6" square, fuel level gauge, and fuel inlet strainer. Tank construction shall be double-wall, with automatic interstitial leak detection and alarm.

D. The interior of the tank shall be epoxy coated and the exterior shall be rust-proofed and painted to match the color of the generator set.

E. Plumbing and wiring between the sub-base tank and the generator set shall be factory-installed.

F. Sub-base storage tank shall be sized for minimum 25 hour full load capacity, minimum 376 gallon, and be provided with appropriately sized and completely piped fill, drain, overflow and vent assemblies. Fuel system shall include: alarms for trouble, leak, low and high fuel. Each alarm shall indicate at the remote annunciator and signal a fault to the security system and Building Management/Automation System (BMS). Provide “Reset” switch to extinguish and clear alarms until next event. Provide piping between the sub-base tank and the main storage tank as specified under Division 23.

G. Provide the following dry contact outputs to the fuel oil pumping control system furnished by Division 23: Low fuel level (at 40% tank capacity), turn lead pump on (at 50% tank capacity), turn lead pump off (at 80% tank capacity), high fuel level (at 90% tank capacity), and leak detection in rupture basin. Provide total of 5 dry contact outputs to Division 23 control equipment.

H. Tank fill and vent piping shall be provided and installed by Division 23.

I. Provide remote fill alarm panel in NEMA 3R enclosure, adjacent to outdoor fuel fill lines. Provide wiring as required between sub-base fuel tank and monitoring panel. Pryco Inc., or approved equal.

2.04 AUTOMATIC TRANSFER SWITCH

A. Provide open-transition electrically-operated, mechanically-held, double-throw automatic transfer switch, quantity and locations as indicated on the drawings, complying with the requirements of UL 1008 and NFPA 110, Level 1.

B. Voltage, ampere rating, and number of poles shall be as indicated. Fault withstand rating shall be suitable for the application, with the indicated upstream circuit protective device. ATS shall be SE (service entrance) rated where installed on the supply side of the service disconnect or as indicated on the drawings.

C. Three-pole switches shall be provided with a fully rated, solid, unswitched neutral terminal. Four-pole switches shall be provided with full-capacity neutral switching.

D. Provide transfer switch mechanisms and control components factory assembled and wired in a wall mounting NEMA 1 enclosure with hinged, lockable door.

E. Electrical operation shall be accomplished by a non-fused momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions. Transfer switches using components of molded case circuit breakers, or contactors not designed for continuous duty repetitive switching between active power sources, are not acceptable.

F. Switch action for double-throw-type switches shall be mechanically held in both directions.

G. Overcurrent devices shall not be part of transfer switch products.

H. Provide switch with a manual operator, capable of transferring the switch to either source position for maintenance purposes. Control circuit shall be disconnected from electrical operator during such manual operation.

I. Provide the following ATS accessories and controls:

1. Close differential voltage sensing on each phase of normal source. Pick-up voltage shall be adjustable from 85 percent to 100 percent of nominal, and dropout shall be adjustable from 75 percent to 98 percent of the pick-up value. Factory set for pick-up at 95 percent and dropout at 85 percent.

2. Time-delay override of normal source voltage sensing shall delay transfer and engine start signals. Adjustable 0 to 6 seconds, and factory set at 2 seconds.

3. Voltage/frequency lockout relay and sensing of the emergency source shall be provided to prevent premature transfer. Voltage pick-up shall be adjustable from 85 to 100 percent of nominal. Factory set to pick-up at 90 percent of nominal. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal. Factory set to pick-up at 95 percent. Provide adjustable time delay for transfer to emergency, 0 to 60 seconds, set at 0 seconds, to permit staggered transfer of multiple switches.

4. System test switch, momentary type, to simulate normal source failure with load, no load and disabled options.

5. Retransfer time delay to normal source, adjustable from 0 to 30 minutes and factory set at 15 minutes. Provide automatic defeat of the delay upon

loss of voltage or sustained undervoltage of the emergency source, provided the normal supply has been restored.

6. Pilot lights to indicate source to which the load is connected.

7. Engine starting contacts, one isolated normally closed and one isolated normally open. Contacts shall be gold flashed or plated and rated 10 amperes at 32 VDC.

8. Engine cool-down time delay to run engine unloaded after retransfer to normal source, adjustable 0 to 30 minutes, set at 5 minutes.

9. Engine-generator exercising timer, adjustable in 15 minute maximum increments, from 0 to 2 hours, for operation once a week, with load/no load transfer.

10. Unassigned Auxiliary Contacts: Two normally open contacts for each switch position, rated 10 amperes at 480 VAC. [Refer to drawing E…. for use of these contacts.]

11. Source Available/Connected Indicating Lights: Provide a indicating light and engraved nameplate for each of the following:

    a. "NORMAL SOURCE AVAILABLE"
    b. "NORMAL SOURCE CONNECTED"
    c. "EMERGENCY SOURCE AVAILABLE"
    d. "EMERGENCY SOURCE CONNECTED"

    e. Supervision of sources shall be via the transfer switch normal and emergency source sensing circuits, respectively.

12. Transfer Override Switch: To override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status. Retransfer shall occur if the emergency source fails and the normal source is available.

13. Selective Load (Elevator/BMS) Disconnect Contacts: Two (2) control contacts which operate with time delay prior to and/or after load transfer and retransfer (approximately 3 second delay).

14. Fire Pump Power Transfer Switch (FPTS): Provide interlock with FPTS and emergency generator ATS to start generator upon failure of normal power source serving the fire pump.

15. Provide each ATS with a factory-installed and wired internal in-phase monitor relay. The relay shall control transfer so it occurs when the two sources are synchronized in phase. The relay shall compare phase relationship and frequency difference between the normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees and only if the transfer can be completed within 60 electrical degrees. In-phase transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage. The transfer switch shall be configurable to control the operation time from source to source (program transition operation). The control system shall be capable of enabling or disabling this feature, and adjusting the time period to a specific value.

16. Door mounted digital meters consisting of voltmeter, ammeter, frequency meter and phase selector switch for phase-to-phase voltage sensing on both normal and emergency sources.

17. Provide a current limiting battery charger to automatically recharge batteries and to maintain at full charge. Charger shall float at 2.20 volts per cell and equalize at 2.40 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC voltmeter, DC ammeter, and fused AC input. AC input voltage shall be 120 volts. Amperage output shall be no less than 10 amperes.

18. Provide load power and load current monitoring to measure load phase and neutral, current, power factor, real power (kW) and apparent power (kVA). Include trouble signal to warn of excessive neutral current resulting from unbalanced or nonlinear loads.

19. Provide load sequencing with LonWorks FTT-10 network communications module for up to eight steps of load with an adjustable time delay for each step on transfer, re-transfer, or both.

2.05 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide Cummins Model OTPC automatic transfer switches or equal as manufactured by one of the following:

1. Automatic Switch Company (ASCO) 7000 Series.
2. Caterpillar CTS

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 SEQUENCE OF OPERATION

A. Provide the following generator and automatic transfer switch (ATS) control and transfer sequence:

1. Normal utility power supply source fails.

2. The ATS sends a start signal to the generator control system.

3. Generator start. Normal operating voltage and frequency are achieved.

4. ATS's sense the availability of an alternate power source or receives a permissive transfer signal from the emergency generator control system to transfer to the alternate source side. Emergency loads are picked up sequentially by the emergency generator's bus in accordance with load priority setting.

5. The load priority settings are as follows:

   a. At 3 seconds, Engine Start.
   b. At 5 seconds, transfer Emergency ATS (ATS-LS).
   c. At 120 seconds, transfer Standby ATS (ATS-SB).

6. Normal utility power supply source returns.

7. ATS's transfer back to normal power supply source. The transfer can be either an open transition (momentary power interruption) or a momentary closed transition (no power interruption), depending on the emergency load requirements and the function and feature of the ATS installed.

8. Generator(s) cool down and shut down.

3.03 INSTALLATION

A. Install and connect generator sets and accessories where indicated, in strict compliance with manufacturer's instructions.

B. Coordinate fuel system, exhaust system, and combustion/cooling air requirements with Division 23.

C. Provide power, control, and signal wiring and connections as required for specified operation. Assure proper phasing of transfer switch normal and emergency source power connections.

D. Coordinate wiring of ATS auxiliary contacts and Selective Load (Elevator/BMS) Disconnect Contacts with Divisions 14 and 23. Provide wiring and conduit from these contacts to mutually-agreed termination locations at the Division 14 and 23 interface equipment. Refer to Sections 14000 and 230923.

E. Install a sign at the service entrance equipment indicating the type and location of the on-site emergency power source. Install a sign on the main grounding box identifying all emergency and normal sources connected at that location.

3.04 FIELD ACCEPTANCE TESTING

A. After completion of the emergency power system installation, perform a complete on site performance test per NFPA 110, Paragraph 7.13.

B. Testing shall be conducted by authorized representatives of the equipment manufacturer(s), and witnessed by the Owner's representatives and any interested local authorities.

C. Provide necessary calibrated test equipment, load banks, temporary cabling and connections, etc. as required to perform the testing in an approved manner.

D. A certified report of test procedures, results, and any corrective measures taken shall be provided to the Owner.

E. Demonstrate operating procedures to Owner's personnel and provide written operating and maintenance instructions.

F. Tests and Approval:

1. Factory Test: The engine-generator shall be tested fully assembled at the factory with a 0.8 PF inductive load bank. The generator set shall conform to the performance criteria of this section.

2. The tests shall be conducted as follows:

a. Operation at full rated load for a minimum of two hours.

b. Records shall be maintained, throughout the test period on water temperature, oil pressure, ambient air temperature, voltage, current, frequency, noise readings, connected load and power factor.

3. On-Site Tests: The complete installation shall be tested for compliance with the Specification following completion of site work with a 1.0 PF resistive load bank for a minimum of 2 hours, or longer if required by NFPA 110 for specific occupancies and site conditions. Testing shall be conducted by representatives of the manufacturer, with required test equipment, witnessed by the Owner. Certified copies of test procedures and results shall be provided to the Owner.

4. On-Site load test shall repeat factory load test as described above and include the following:

   a. Check fuel, lubricating oil, and antifreeze in liquid cooled models for conformity to the manufacturer's recommendations under environmental conditions present.

   b. Test (prior to cranking engine) for proper operation of accessories that normally function while the set is in a standby mode. Accessories include: engine heaters, battery chargers, generator and control enclosure strip heaters and remote annunciators.

   c. Check (during start-up test mode) for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and phase rotation.

   d. Test, by means of simulated power outage, automatic start-up by remote-automatic starting, transfer of load, and automatic shutdown. Prior to this test, adjust transfer switch timers for proper system coordination. Monitor throughout the test engine temperature, oil pressure, battery charge level, generator voltage, amperes, and frequency.

   e. Perform manual transfer of loads to generator simulating loss of automatic transfer switch operation.

   f. Test for proper interfacing and sequences of operation of ATS auxiliary and selective load shedding contacts with equipment and sequences described herein, on the drawings, and in Division 23 Section 230923.

   g. Upon completion of installation, demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Initial testing and retesting to be at no cost to Owner.

5. Provide complete instructions, consisting of three (3) operating and maintenance manuals, parts books, dimensional drawings. Separate unit wiring diagrams, and schematics and interconnection wiring diagrams shall be provided.

6. Owner Orientation: A representative of the supplier shall meet the Owner at the time of start up, and shall review the operation and parts books, starting and control methods, and recommended preventative maintenance procedures.

a. Furnish training as follows for a minimum of four employees of the system user:

(1) Training in the receipt, handling and acknowledgement of alarms.

(2) Training in the system operation including manual control of output functions from the system control panel.

(3) Training in the testing of the system including logging of detector sensitivity, field test of devices and response to common troubles.

(4) The total training requirement shall be a minimum of 4 hours or as required by the Owner, but shall be sufficient to cover the items specified.

G. Refill fuel oil storage and sub-base tanks so that Owner is provided with full tanks upon successful completion of testing. This shall be at no cost to the Owner.

3.05 WARRANTY

A. Provide five (5) year comprehensive extended coverage for standby power applications. The complete electrical power system (generator set, controls, and associated switches, switchgear and accessories) as provided by the single source manufacturer shall be warranted by the manufacturer against defects in materials and workmanship for a period of five (5) years or 1500 hours, whichever occurs first from the date of system start-up. Coverage shall include parts, labor, travel expenses, and labor to remove/reinstall said equipment per the manufacturer's standard published limited warranty. There shall be no deductibles applied to said warranty.

3.06 MAINTENANCE SERVICES

A. The contractor or manufacturer shall offer for the owner's consideration at the time of system submittal a priced inspection, maintenance and repair contract in full compliance with the requirements of NFPA 110.

1. The services offered under this contract shall be performed at no charge during the first year after system acceptance and the owner shall have the option of renewing for single or multiple years up to five years at the price quoted upon completion of the warranty period.

2. The contractor performing the contract services shall be qualified and listed to maintain ongoing certification of the completed system to the UL for specific installed system listing.

END OF SECTION 26 32 00

SECTION 26 41 13

LIGHTNING PROTECTION SYSTEM

PART 1 – GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this Section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this Section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this Section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

1.03 WORK INCLUDED

A. The contractor shall design, furnish and install equipment and cable as necessary to provide a complete UL Master Label lightning protection system for the project.

1.04 SUBMITTALS

A. Submit manufacturers' technical product data for components to include but not necessarily limited to: air terminals, chimney points, base mounts, connectors, clamps, splices, cables, fasteners, supports, hardware, exothermic welds, ground electrodes, corrosion protection and sealants for waterproofing.

B. Provide layout and arrangement drawings for each structure. Include sufficient detail to describe each air terminal location, primary conductor, secondary conductor, roof penetration, down conductor, ground connection, counterpoise, bonding to adjacent metal bodies and bonds to electric, water, gas, telephone, cable television and other utilities, as applicable.

C. Provide installation details and specification notes to include: each typical air terminal, chimney point, roof penetration, splice, ground connection, bond, cable sleeve or other details specific to this project.

D. Earth resistance test report.

PART 2 – PRODUCTS

2.01 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Provide lightning protection system materials and components of types, sizes, ratings, and Class of Service required, which comply with manufacturer's standard materials, design, and construction in accordance with published product information, and as required for complete installation. Where type of components or materials are not otherwise indicated, comply with NFPA 780, Lightning Protection Institute (LPI), and UL96 standards.

B. Materials:

Provide lightning protection materials as described below. Aluminum lightning protection materials are not acceptable for this project except where required by UL for galvanic corrosion mitigation.

Air Terminals:	Corrosion Resistant Tinned Solid Copper
Air Terminal Bases:	Tinned Bronze with Stainless Steel Bolts & Washers
Connectors/Fittings:	Tinned Bronze with Stainless Steel Bolts & Washers
Conductors:	Corrosion Resistant Tinned Copper
Ground Rods:	Copper-clad steel, 3/4" diameter, 10 feet long.
Raceways:	Non-metallic: Where exposed to physical damage outdoors and less than six feet above grade, stub-ups or penetrations through concrete slabs, in corrosive locations and where shown on drawings.
	Electrical metallic tubing (EMT): Where exposed to physical damage in building interiors and less than six feet above finished floor.

C. Coordinate the products furnished with field and installation conditions. Furnish products that are compatible with the building components to which attached.

D. Air terminals at roof parapets shall be equipped with flexible adapters and stainless steel safety chain to allow façade maintenance equipment and personnel to work in these areas. Provide Harger 12x series or approved equal.

E. Air terminals adjacent to occupied roof areas shall include tip protection to minimize personnel injuries caused by accidental falls. Provide Harger Stat 2000 or approved equal.

2.02 UL CERTIFICATION

A. Provide the Owner with UL Master Label for each system that is suitable for fastening to building for display purposes. Comply with UL 96A, "Master Labeled Lightning Protection Systems".

2.03 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the requirements, provide equipment manufactured by one of the following:

1. Harger
2. Warren
3. East Coast Lightning Equipment

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 INSTALLATION OF LIGHTNING PROTECTION SYSTEMS

A. Install lightning protection systems in accordance with equipment manufacturer's written instructions, and in compliance with applicable requirements of NEC, NFPA 780, LPI-175, and UL 96A to ensure lightning protection systems comply with requirements.

B. Coordinate with other work, including electrical wiring, site, and roofing work, as necessary to interface installation of lightning protection system with other work. Refer to architectural drawings for roof and building configurations and details.

C. Cut and seal roof penetrations in strict accordance with roof installer's written instructions.

D. Arrange for any necessary UL inspections of concealed work prior to its being closed in.

E. Install ground rods vertically, top of rod 12 inches below finished grade.

F. Install underground ground cables minimum 18 inches below finished grade; utilize one-inch Schedule 40 PVC pipe sleeve where cables run through concrete slabs or foundations.

G. Install conductors with direct paths from air terminals to ground connections; avoid sharp bends and narrow loops, minimum 90 degrees per bend and 8-inch or greater radius.

H. Unless otherwise indicated or approved by architect, conceal conductors within building finishes.

I. Use exothermic welding, Cadweld or equivalent, for underground system connections and connections to structural steel.

3.03 GROUNDING AND BONDING

A. Provide equipment grounding and bonding connections to assure permanent and effective grounds and bonds. Follow manufacturer's requirements for proper installation of bonding and grounding connectors and fittings.

B. Bond rooftop metallic housings, vent pipes, enclosures, ladders and railings and other metal objects to the lightning protection system. Use side mounted terminal bases and avoid top mounted bases to maintain water tightness of enclosures whenever possible.

C. Bond lightning protection conductors to metallic protective sleeves, building steel, well casings, water and interior metal piping, electrical, cable, data and telephone services.

D. Do not use piping and enclosures as conducting elements of the lightning protection system.

3.04 TESTING

A. Upon completion of installation of lightning protection system, test resistance-to-ground (earth connection) using three-point ground resistance measuring equipment as manufactured by Biddle or approved equivalent. Where tests indicate resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms or less, by driving additional ground rods, or adding buried mesh grids. Chemical treatment of the soil is not acceptable as a means to reduce earth resistance. Retest to demonstrate compliance. Include test results with record drawing submittal.

3.05 ADMINISTRATION

A. The installer shall submit UL Master Label certification letter to the owner bearing his name and address for each structure that is protected under this project. The metal plate shall be attached near a down conductor to a wall or other conspicuous location approved by the architect.

END OF SECTION 26 41 13

SECTION 265000

LIGHTING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Work of this section shall be governed by the Contract Documents. Provide materials, labor, equipment, and services necessary to furnish, deliver and install work of this section as shown on the drawings, as specified herein, and/or as required by job conditions.

1.02 REFERENCES

A. Perform the work of this section in accordance with the requirements of Section 260000 General Provisions and Section 260500 Basic Materials.

B. See architectural reflected ceiling plans for requirements of architectural luminaires not included herein.

1.03 MATERIALS, EQUIPMENT AND SYSTEMS

A. Factory wiring of components shall conform to state and local codes and laws.

B. The design is based on equipment of the named manufacturers. Equipment of other manufacturers will be considered, subject to acceptability in the Engineer's judgment and opinion. The equipment must conform to the dimensions established by the drawings for mechanical spaces and other clearances.

C. Materials and products provided shall be suitable for, and where applicable UL or CSA listed and labeled for, the intended use or application.

1.04 SUBMITTALS

A. Submit manufacturers' technical product data for luminaires and components, including the following:

1. Dimensions.
2. Materials and construction.
3. Finishes.
4. Photometric data.
5. Ballasts (including normal, emergency and dimming).
6. Lamps.
7. Mounting accessories and details.

B. Submit scaled and dimensioned shop drawings for custom-fabricated luminaires, and for custom field assemblies.

PART 2 - PRODUCTS

2.01 LUMINAIRES

A. Provide luminaires of sizes, types and ratings indicated, complete with, but not limited to, housing, lenses, louvers, baffles, lamps, lamp holders, reflectors, ballasts, starters, wiring and mounting accessories.

B. Luminaire types are indicated on schedules and drawings. Luminaires must comply with minimum requirements as stated therein or in the listed manufacturers' published data. Review architectural drawings and specifications to verify ceiling types, modules, and suspension systems appropriate to installation.

C. Subject to compliance with requirements and acceptance by the Architect, manufacturers other than those listed will be considered, unless indicated "No Substitutions".

D. Luminaire types as specified constitute the basis of design and provide required illumination levels and energy compliance as established by design calculations. Alternative fixtures proposed as substitutes shall be accompanied by full area illumination calculations. The calculations shall establish equal or better performance before being considered for approval.

E. Coordinate with the ceiling system supplier to ensure that the luminaires and components supplied will be fully compatible with the ceiling system construction.

F. Recessed incandescent luminaires shall have built-in, automatic reset thermal protection, or be of low-temperature construction, as required by NEC 410-65 (c), and shall be provided with feed-through wiring boxes.

G. Provide electrical wiring within luminaire suitable for the ampacity and operating temperature.

H. Sockets for medium bi-pin fluorescent lamps shall be knife-edge type.

I. For exterior luminaires, hardware shall be stainless steel, even if painted; unpainted steel shall be hot-dipped galvanized after fabrication. Coordinate mounting hardware with the pole or surface to which mounted; bracket material and finish shall match the luminaire. Dissimilar metals shall be separated by non-conductive material to prevent galvanic action.

J. Lenses for fluorescent luminaires shall be prismatic acrylic, pattern 12, minimum 0.156 inch thick. Provide gasketing between enclosure and frame and between frame and luminaire housing.

K. Provide iridescent free reflectors and baffles for fluorescent luminaires.

L. Provide internal fixture disconnecting means for fluorescent luminaires equipped with double ended lamps or ballasts supplied from multi-wire circuits per NEC 410.73(G).

2.02 BALLASTS

A. Ballasts shall be Class P, thermally protected, ANSI C82.11-listed, U.L., CSA or ETL-listed, and compatible with the luminaires, lamps, and voltage systems specified. Include end-of-life protection for detecting excessive voltages across the lamp that can occur when the lamp nears end of life and shuts the ballast down safely before these high voltages can do harm or damage. Provide universal voltage ballasts rated for 120 – 277 VAC input unless otherwise indicated. Where applicable, ballasts shall comply with Public Law 100-357 and local utility energy conservation criteria for energy efficiency, and with the requirements of FCC Part 18. Ballasts shall meet FCC EMI/RFI emission requirements for consumer equipment. Ballasts shall contain no PCB's.

B. Fluorescent ballasts for rapid-start lamps shall be high power factor, high frequency electronic type, sound rated A or better. Input Total Harmonic Distortion (THD) shall be less than 10% and ballast factor shall exceed 90%. Ballasts shall withstand line transients as defined in ANSI/IEEE C62.41, Category A. Ballasts shall be manufactured by Advance, Magnetek, Robertson or Sylvania, and shall come with a manufacturer's 5 year replacement warranty, including labor costs.

C. Fluorescent ballasts for pre-heat lamps shall be high power factor, trigger-start type. Pre-heat ballasts with starters are not acceptable.

D. Three-lamp fluorescent luminaires shall be provided with one 1-lamp and one 2-lamp ballasts, unless otherwise indicated. The center lamp of each shall be connected to the 1-lamp ballast.

E. Ballasts for compact fluorescent and T-5 twin-tube lamps shall be electronic type. Total harmonic distortion shall be less than 10%. Ballast shall maintain constant output for a line voltage variation of +/- 10%, have transient voltage protection per ANSI C62.41 Category A, be sound rated A, have power factor and ballast factor >90% throughout dimming range, start lamp at minimum temperature of 50°F, and have lamp end of life detection and shutdown circuit.

F. Emergency ballasts for fluorescent lamp emergency power supply shall be suitable for installation in ballast compartment of fluorescent luminaire. For luminaires not large enough to enclose the emergency ballast, provide a separate NEMA 1 enclosure accessible by removing the luminaire or ceiling tiles. Ballast output shall power each lamp for a minimum of 1100 lumens for 90 minutes. Battery shall be sealed lead calcium type, 5 year warranty, not pro-rated, with 7 to 10 year life expectancy. Include TEST switch and AC ON indicator light, installed to be operable and visible without disassembling luminaire. Emergency ballasts shall be Bodine B-50 ST (self-test) for T8 lamps, B35ST for T5 lamps, and B-84C ST for compact lamps and LP600 ST (self-test) for low profile and space-limited fixtures or approved equals. Include Bodine Model KTS remote keyed test switch as indicated on drawings.

G. Where installed outdoors, in unheated areas, cold storage areas or areas below 50^{o}F fluorescent ballasts shall be low-temperature type, suitable for 0^{o}F operation. Emergency ballasts installed in unheated areas shall be Bodine B50 Cold-Pak for linear fluorescent lamps, B4CF for compact fluorescent lamps or approved equals to withstand temperatures ranging from -4 ^{o}F to 131 ^{o}F and providing minimum 1200 lumens.

H. Provide HID lamp ballasts capable of operating lamp types with ratings indicated; constant wattage autotransformer magnetic type (CWA), high power factor (>0.90), multi-tap (120/208/240/277 volt), core and coil assembly encapsulated in non-melt resin; install capacitor outside ballast encapsulation for easy field replacement. Remote ballasts shall be provided by the fixture manufacturer with the proper lamp ignitor for remote applications. Provide wiring in accordance with manufacturer's recommendations to withstand lamp starting voltage and operating temperature. Coordinate installation requirements with manufacturer to assure code compliant installation.

I. Emergency ballasts for 175, 250 and 400 watt HID lamps with constant wattage autotransformer (CWA) ballasts shall maintain lamp arc for a minimum of two minutes until normal power is restored or emergency power takes over. Emergency ballasts shall be remote mounted up to 15 feet from HID fixture in a separate NEMA 1 enclosure. Battery shall be field replaceable, nickel cadmium type, 5 year warranty, not pro-rated, with 7 to 10 year life expectancy. Include charging indicator light. Emergency ballasts shall be Bodine Arc Keeper series or approved equal.

J. Fluorescent Electronic Dimming Ballasts

1. Dimmer shall be rated to control T-12, T-12 high output, T-8, T-5 and T-5 high output lamps at 120 VAC with the use of an interface. Lamps on the same circuit must have the same current rating (i.e., T-8), but may be different lengths (i.e., 3', 4').

2. Ballasts for fluorescent fixtures shall be Lutron Hi-lume "FDB" (1% dimming) series and Compact SE (5% dimming) series. See fixture schedule, and/or dimming schedule for specific ballast model numbers.

3. Ballasts for LED fixtures shall be Lutron Hi-Lume series. Contractor shall coordinate LED dimming control with LED manufacturer.

4. Provide remote wireless control where indicated on the drawings. Remote handheld device shall provide full range dimming with adjustable setpoints from 20-60 fc (210-640 lux) and ability to control up to 20 standard dimming ballasts in one zone.

K. The dimming performance shall be as follows:

1. One- and two-lamp ballasts shall track evenly, with no perceptible difference in light levels for the same type lamps.

a. Different lamp lengths on the same circuit shall track evenly, with no perceptible difference in light levels for the same type lamps.

b. Ballasts shall be inaudible with no apparent humming or buzzing at any point in the dimming range.

c. Ballasts shall have: power factor greater than .95, ballast factor equal to .93, total harmonic distortion less than 10%, and lamp current crest factor less than or equal to 1.6.

d. Ballasts shall be inaudible in a 27dB ambient throughout the dimming range.

e. Ballasts shall be capable of striking lamps at any light level without first flashing to full light.

f. Ballasts shall comply with FCC Part 18 regulations and shall not interfere with other properly installed electrical equipment.

g. Ballasts shall have a minimum starting temperature of 10°C.

2.03 LAMPS

A. Provide lamps as indicated on drawings or schedules, or to suit the specified luminaires.

B. Fluorescent lamps shall be by the same manufacturer and shall be of the same color (3500K) with a Color Rendering Index (CRI) of 82 or higher for compact lamps and 85 or higher for other fluorescent lamps, unless otherwise indicated or

required. Lamps of the same wattage, size and shape shall be identical. Fluorescent lamps shall be low-mercury types, and shall be EPA TLCP-compliant. Provide GE “Ecolux” series, Philips “ALTO” series, or Sylvania “Ecologic” series.

C. Lamps shall be rated for dimming duty by the manufacturer where dimming control is shown on the drawings.

D. Incandescent lamps shall be 120 volt, inside-frosted (except PAR types), sizes and bases as indicated or required for luminaire compatibility.

E. High-intensity-discharge (HID) lamps shall be of the type and wattage specified, and compatible with the specified luminaires. High pressure sodium lamps for interior luminaires shall be diffuse-coated. Metal halide lamps for interior luminaires shall be phosphor-coated. Metal halide lamps for open luminaire operation shall be ANSI “O-rated” and include a quartz shroud around the arc tube to restrict end-of-life rupture. HID lamps for exterior luminaires shall be clear.

2.04 ACCESSORIES

A. UV Filtering Sleeves

1. Provide ultraviolet filtering sleeves designed to fit fluorescent lamps in luminaires shown on drawings and/or schedules. Sleeves shall be re-usable tubular design with removable endcaps for lamp replacement. Sleeves shall filter out UV rays from 0 to 385 nanometers for a total filtration of 90% of the total UV output of the lamp. Sleeves shall have a minimum 10 year expected life. Sleeves shall only be used on lamps operated on electromagnetic ballasts or electronic high-frequency ballasts designed to prevent overheating of the lamps at end of life.

2. Lamps shall be provided with "PAL" Ultra-violet (UV) light filtering sleeves as manufactured by A.L.P. Lighting and Ceiling Products, Inc., Model #PAL40T8CUV with #PALT8 endcaps or approved equal.

B. UV Filtering Lenses

1. Provide ultraviolet filtering lenses designed to fit fluorescent luminaires shown on drawings and/or schedules. Acrylic lens materials shall meet requirements for light diffusers and lenses and be test certified to ASTM standards for burn rates and smoke density. Products shall be KSH, Inc. Type 23 UVBWF lens or approved equal.

2.05 ACCEPTABLE MANUFACTURERS

A. Cooper
B. Lithonia
C. Thomas
D. Hubbell
E. General Electric
F. Lightolier
G. Colombia/Prescolite/Moldcast

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 260500 BASIC MATERIALS.

3.02 INSTALLATION OF LUMINAIRES

A. Install luminaires at locations and heights as indicated, in accordance with luminaire manufacturers' written instructions, applicable requirements of NEC and NEMA standards, and with recognized industry practices, to ensure that luminaires fulfill requirements.

B. Electrical drawings show luminaire types, quantities, circuiting and approximate locations. Exact locations shall be as per the architectural drawings. Where exact dimensions are not given luminaires shall generally be centered in the room or area, equally spaced, sides parallel to walls, level, and in a straight line (for rows). Where conflicts occur or where exact locations cannot be determined, request clarification from the Architect.

C. Provide necessary boxes, canopies, stems, chain, and mounting hardware for a complete installation.

D. Luminaire suspension and mounting methods shall be capable of supporting the weight of the luminaire, plus the forces applied during re-lamping and maintenance.

E. Pendant fluorescent luminaires shall be stem or chain suspended as indicated. Individual luminaires shall have two supports, equally spaced from each end. Continuous rows with rigid couplers shall have supports near the center of each luminaire, equally spaced. Stem-supported luminaires shall be wired via one of the stems. In finished or semi-finished areas, outlet boxes and stem mountings shall be provided with decorative canopies. Chain-supported luminaires shall be wired with 3-conductor Type MC cables, strapped to the chain to provide a neat

appearance, with appropriate cable connectors at each end. Pendant luminaires shall be hung plumb and level, parallel and perpendicular to walls.

F. In unfinished areas and areas without finished ceilings including but not limited to Mechanical Equipment Rooms, storage rooms and utility corridors, install luminaires after completion of ductwork and piping, in approximately the locations shown. Luminaires shall not be mounted above ducts or pipes where rendered inaccessible or where the light will be substantially blocked. Luminaires shall not be supported from ductwork or piping. In Mechanical Equipment Rooms mounting heights and exact locations shall be field-determined, but in no case shall mounting height be less than 7'-0". Provide necessary support as described in Section 260500.

G. Continuous rows of luminaires shall be rigidly aligned to provide a true straight-line appearance.

H. 2' x 2' fluorescent luminaires in any one area or corridor shall be mounted with the lamps oriented in the same direction.

I. Ceiling mounted lighting track sections, recessed downlights, outlet boxes, exit signs, etc. shall be securely mounted to the ceiling grid system and not supported by the acoustical ceiling tile only. Track shall be installed parallel and perpendicular to the grid system, unless otherwise indicated.

J. Lay-in troffers for exposed grid ceilings shall be provided with hold-down clips to prevent T-bar spread and subsequent falling of luminaire.

K. Recessed luminaires weighing more than fifty pounds shall not be installed directly on the concealed or exposed ceiling spline of a lightweight, mechanical acoustical ceiling system. Such fixtures shall be supported from the channel iron or the building structure.

L. Surface or pendant type luminaires, regardless of their weight, shall not be mounted directly on the concealed or exposed ceiling spline of lightweight, mechanical acoustical ceiling system. Such luminaires shall be supported from the channel iron or the building structure.

M. Install flush mounted luminaires to eliminate light leakage between luminaire frame and finished surface.

N. Provide plaster frames for recessed luminaires installed in other than suspended grid types acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.

O. Support surface mounted luminaires greater than 2' in length at a point in addition to the outlet box luminaire stud.

P. Extra care shall be taken in the handling of parabolic baffle and louver assemblies. Factory-installed plastic protection should be left intact until just before final job completion.

Q. Fluorescent lamps shall be stored lying flat. Do not stand on end.

R. Install exit signs to be readily visible per Code and adjust locations up to five feet from locations shown on drawings at no additional cost.

S. Install and operate UV filtering sleeves luminaires to insure proper fit. If any condition of incompatibility with the proposed luminaires is found, the Contractor shall submit for approval a luminaire of equal appearance and quality that has been found to be compatible with the lamp/sleeve combination.

3.03 ADJUSTING AND CLEANING

A. Clean luminaires of dirt and debris upon completion of installation.

B. Protect installed luminaires from damage during remainder of construction period.

C. Adjust the aiming of adjustable floodlights, track-mounted luminaires, wall-wash luminaires, etc. as directed, or as required to direct the illumination to the intended locations. Where applicable, such adjustments shall be performed at night.

D. Level and grout pole and bollard bases.

3.04 MAINTENANCE STOCK

A. At date of substantial completion, turn over to Owner, in original factory packaging, spare lamps equaling 10% of the installed quantity of each type, and spare ballasts equaling 5% of the installed quantity of each type, minimum two (2) of each type.

3.05 LUMINAIRE SCHEDULE

A. Refer to electrical drawings for luminaire descriptions and schedules.

END OF SECTION 26 50 00

SECTION 28 31 00

ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 SCOPE & RELATED DOCUMENTS

A. The work covered by this section of the specifications includes the furnishing of labor, equipment, materials, and performance of each operation in connection with the installation of the Fire Alarm System as shown on the drawings and as herein specified.

B. The requirements of the conditions of the Contract, Supplementary Conditions and General Requirements, apply to the work specified in this section.

C. The complete installation is to conform to the applicable sections of NFPA-72, Local Code Requirements and National Electrical Code with particular attention to Article 760.

D. The work covered by this section of the specifications is to be coordinated with the related work as specified elsewhere under the project specifications.

E. Regulatory Requirements - Air Sampling Smoke Detection System

1. Codes and Permits: Conform to the local code requirements applicable to this section. Obtain and pay any necessary permits prior to beginning work involved in this section.

2. The air sampling system shall be UL Listed and FM approved.

3. The air sampling system shall be U.L. listed. VESDA® as the PRIMARY DETECTION (e.g., no other detection in the space) - The VESDA® detector shall be U.L. 268 listed for Special Applications, also suitable for Open Area Protection.

1.02 QUALITY ASSURANCE

A. Each item 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 "U.L." label. Equipment provided shall be listed under UL 864 9th Edition to insure the latest revision of control equipment. Equipment that does not have UL 864 9th Edition or has 9th Edition pending will not be approved. Manufacturer shall provide copy of UL 9th Authorization letter if requested. Control

equipment is to be listed under UL category UOJZ as a single control unit. Partial listing shall not be acceptable.

B. The equipment and installation supervision furnished under this specification is to be provided by a manufacturer who has been engaged in production and/or installation of this type (software driven) of equipment for at least ten (10) years, and has a fully-equipped service organization within fifty (50) miles of the installation.

C. Before commencing work, submit data showing that the contractor has successfully installed fire alarm system of the same type and design as specified or that they have a firm contractual agreement with a subcontractor having the required manufacture's training and experience. The contractor will include the names and location of at least two installations of similar size and complexity where the contractor, or his subcontractor have installed such systems.

D. Control equipment must have transient protection devices to comply with UL864 requirements. Provide an isolated loop protector device on any circuit including power, telephone, signal, initiating device, or notification appliance device circuit that extends beyond the main building by either aerial, underground, or other method.

E. Qualifications - Air Sampling Smoke Detection System

1. The manufacturer shall have a minimum of 15 years production experience in the manufacturer and design of high sensitivity aspiration-type smoke detection systems.

2. The manufacturer shall be certified as meeting ISO 9002 for manufacturing.

3. Technology

a. Both Light Scattering and Particle Counting shall be utilized in this device as follows:

The Laser Detection Chamber shall be of the mass Light Scattering type and capable of detecting a wide range of smoke particle types of varying size. A particle counting method shall be employed for the purposes of preventing large particles from affecting the true smoke reading

monitoring contamination of the filter (dust & dirt etc.) to automatically notify when maintenance is required.

Note: The Particle counting circuitry shall not be used for the purpose of smoke density measurement.

The Laser Detection Chamber shall incorporate a separate secondary clean air feed from the filter; providing clean air barriers across critical detector optics to eliminate internal detector contamination.

The detector shall not use adaptive algorithms to adjust the sensitivity from that set during commissioning. A learning tool shall be provided to ensure the best selection of appropriate alarm thresholds during the commissioning process.

b. Equipment Supplier
The equipment supplier shall be authorized and trained by the manufacturer to calculate/design, install, test and maintain the air sampling system and shall provide a copy of the certificate with his quotation/proposal.

1.03 SHOP DRAWINGS

A. Prior to submittal of drawings:

1. First: Obtain Architect's approval for revisions to layouts shown on Contract Documents.
2. Second: Submit shop drawings to the local Fire Marshal or other Authority Having Jurisdiction for review and approval prior to commencing construction.

B. Submit shop drawings for the following:

1. Intelligent addressable fire alarm control panel, manual pull stations, heat detectors, analog smoke detectors, alarm monitoring modules, supervised control modules and accessories.
2. Conventional non-addressable devices as required for performance to this specification.
3. Audible and visual evacuation signals and devices.
4. Wiring and conduit to include circuit load and spare capacity.
5. Detailed sequence of operation.
6. Detection layout showing location of VESDA air sampling detection system tubes, junction boxes, control panels, and interconnecting wiring.

C. Data describing more than one type of item shall be clearly marked to indicate the type the contractor intends to provide for a given application. The reviewing authority will assume that options not crossed out in submittal material will be furnished for the project. Submittal material shall be complete. Partial submittals will not be accepted. Submit copies of UL listing or FM approval data showing compatibility of the proposed device or appliance and the panel being provided.

D. Complete drawings covering the following shall be submitted for the proposed system:

1. Floor plans showing initiating, end of line, supervisory, notification appliances, and output control devices.

2. Wiring diagrams showing points of connection and terminals used for electrical connections to the existing system devices and panels.

3. Submit project-specific, complete riser diagram showing interconnections of panels, modules, and point-to-point wiring between devices including wire types and major junction boxes required for the project.

4. A complete proposed system database including a description of logic strings, control by event programming and point identification labels on a compact disk (CD) and in a formatted printed form, required for off site editing, uploading and downloading shall be submitted for evaluation by the Owner. A programming manual shall accompany the submitted program and shall be adequate to allow understanding, operation and editing by the system owner.

E. Submit a schedule of initiating devices, listing device type, location, zone (if applicable), and software address.

F. Submit a matrix or table listing each output control function (e.g. fan shutdown, door release) and its corresponding initiating addresses.

G. Submit calculations for the sizing of power supplies, batteries, and audio amplifiers (where applicable).

H. Submit a copy of the field installer's NICET Level 3 certificate in Fire Protection Engineering Technology, Fire Alarm Systems.

I. For use in system test, a complete operation and maintenance manual with two sets of proposed installation drawings shall be submitted.

1. The following information shall be inscribed on the cover:

   a. "OPERATION AND MAINTENANCE MANUAL"
   b. Building location.
   c. The name of the contractor, system manufacturer and system subcontractor.
   d. The name and phone number of the fire department required to respond to alarms at the project location.

2. The manual shall be legible and easily read with large drawings folded and contained in pockets. Included in the manual shall be circuit drawings, wiring and control diagrams with data to explain detailed operation and control of each item of equipment and a control sequence describing start up instructions. Included shall be installation instructions, maintenance instructions, safety precautions, test procedures, performance data, and software documentation.

B. Upon completion of the installation, "as-built" record drawings shall be submitted on each system before final acceptance of the work. Furnish to the Engineer a set of "as-built" record drawings including updated system riser diagrams for each system. The record drawings masters shall be on reproducible vellum uniformly sized as required for legibility and reproduction and on a compact disk (CD) in a DXF format suitable for use in a CAD drafting program. Record drawings shall additionally be annotated with the following:

1. Voltage drop calculations on a dedicated sheet.

1.04 SUBMITTALS

A. Submit manufacturers' technical product data for fire alarm system equipment and devices, and including description of operation, specifications, dimensions and finishes. Clearly mark options and features furnished, and strike out items, options, and features not being furnished.

B. Submit a minimum of (2) additional Factory Authorized Independent Distributors within 50 miles of the project that can maintain, service, and add to the proposed system.

1.05 GENERAL

A. Furnish and install a complete Fire Alarm System as described herein and as shown on the plans. The system shall be microprocessor-controlled, intelligent reporting, electrically supervised, low-voltage, power-limited, non-coded, utilizing one-way voice communication with individually addressable manual

and automatic initiating devices and circuits, and individually addressable output control functions. The system shall use closed loop initiating device circuits with individual zone supervision, individual notification appliance circuit supervision, incoming and standby power supervision.

1. Include a control panel, manual pull stations, automatic fire detectors, audible devices, flashing lights, remote annunciator, remote control devices, conduit and wiring, connections to devices, outlet boxes, junction boxes, and other necessary material for a complete operating system.

2. The building shall have an emergency voice alarm communications system. The digitized voice message shall notify occupants that a fire condition has been reported. Provide emergency manual voice override.

3. The fire alarm control panel shall allow for loading or editing special instructions and operating sequences as required. The system is to be capable of on site programming to accommodate and facilitate expansion, building parameter changes or changes as required by local codes. Software operations are to be stored in a non-volatile programmable memory within the fire alarm control panel. Loss of primary and secondary power shall not erase the instructions stored in memory.

B. To accommodate and facilitate job site changes, initiation circuits shall be individually configurable on site to provide either alarm/trouble operation, alarm only, trouble only, current limited alarm, no alarm, normally closed device monitoring, a non-latching circuit or a alarm verification circuit.

C. If equipment of another manufacturer is submitted for approval, the contractor shall state what, if any, specific points of system operation differ from the specified points of the system operation. This differentiation report is to reference every paragraph of this specification. The following manufacturers are pre-approved for bidding purposes on this project:

1. Siemens Fire Safety
2. Honeywell/Notifier
3. Tyco/Simplex Grinnell
4. UTC Fire & Security/Edwards

1.06 OPERATION

A. Provide system with the following operation and control features:

1. Alarm reporting to remote supervising station (coordinate exact requirements with the Owner or local Fire Department).
2. Alarm verification for automatic smoke detectors.
3. Subsequent alarm (second zone in alarm re-sounds the audible signals after silencing of the first alarm).
4. Interface with pre-action sprinkler systems.
5. Monitor fire pump controller (Per NFPA 20).
6. Monitor emergency generator per NFPA 110.
7. Control of auxiliary services:
    a. Magnetic door holder release.
    b. Release of magnetic door locks.
    c. Close smoke dampers.
    d. Operation of automatic smoke vents.
    e. Close fire shutter doors and motorized fire-rated doors.
    f. Interface with kitchen hood suppression systems.
    g. Interface with building fuel gas control panels and valves.
8. Detector sensitivity, status, adjustment, and testing from the control panel and day/night sensitivity control.
9. Alarm initiation and bell activation from sprinkler flow switches.
10. Alarm initiation from smoke detector operated doors and smoke hatches.
11. Supervisory indication from sprinkler valve tamper switches, with ring back upon correction.
12. Electrical supervision of output control circuits.
13. System status reports consisting of hard copy, English-language printout, with time and date stamp, of system input and output activity.
14. Digital alarm communication to remote station via telephone line.

B. Under normal condition the front panel shall display a "SYSTEM NORMAL" message and the current time and date.

C. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory, or Trouble) shall flash. The panel audible signal shall sound steadily for alarm conditions and pulse for trouble and supervisory conditions.

D. The panel shall display the following information relative to the abnormal condition of a point in the system:

1. Custom location label (40 characters minimum)
2. Type of device (i.e. smoke, pull station, waterflow)
3. Point status (i.e. alarm, trouble)

These three characteristics relative to an abnormal condition of a point shall be displayed simultaneously.

E. Pressing the appropriate acknowledge button shall acknowledge the alarm or trouble condition. The acknowledge functions may be passcode protected. Systems not capable of password protected manual command operations shall provide key operated switches for these functions. Function key switches shall be keyed differently from any other keyed switches or locks used within the system.

F. After all points have been acknowledged, the LED's shall glow steady and the panel audible signal will be silenced. The total number of alarms, supervisory, and trouble conditions shall be displayed along with a prompt to review each list chronologically. The end of the list shall be indicated. This feature shall be duplicated by the remote annunciator panel(s) with both the main fire alarm control panel and remote annunciator panel(s) responding the same way.

G. Alarm Silencing

1. Alarm silencing shall be duplicated by the remote annunciator panel(s) with both the main fire alarm control panel and remote annunciator panel(s) responding in like manner.
2. Should the "Alarm Silence" button be pressed alarm signals shall cease operation.
3. Signals shall not be silenced during alarm silence inhibit mode.

H. System Reset

1. The "System Reset" button shall be used to return the system to its normal state after an alarm condition has been acknowledged and cleared by authorized personnel. The display shall step the user through the reset process with simple English language messages. Messages shall provide operator assurance of the sequential steps (i.e.: "IN PROGRESS", "RESET COMPLETED", and "SYSTEM NORMAL") as they occur, should alarm conditions be cleared.

I. Fan Reset

1. The "Fan Reset" button shall be used to return the previously shutdown mechanical systems to their normal state after an alarm condition has been acknowledged and cleared by authorized personnel. The display

shall step the user through the reset process with simple English language messages. Messages shall provide operator assurance of the sequential steps (i.e.: "FAN RESET IN PROGRESS", "FAN RESET COMPLETED", and "FAN SYSTEMS NORMAL") as they occur, should alarm conditions be cleared.

J. Function Keys

1. Additional function keys shall be provided to access status data for system points. As a minimum the status data shall include Disable/Enable Status, Verification Tallies of Initiating Devices, Acknowledge Status, etc.

K. History Logging

1. In addition to any required printer output, the control panel shall have the ability to store a minimum of three hundred (300) events in an alarm log plus a minimum of three hundred (300) events in a separate trouble log. These events shall be stored in a battery protected random access memory (RAM). Systems not having discrete alarm and trouble logging memory shall include an alternative supervised (eg: floppy drive, tape cassette, zip drive) historic recording method with battery backup. Real time and date shall accompany history event recording.

L. Walk Test with History Logging

1. The system shall be capable of being tested by one person. While in testing mode, the alarm activation of an initiating device shall be silently logged as an alarm condition in the historical data file. The panel shall automatically reset itself after logging of the alarm.

M. Access Levels

1. There shall be a minimum of four (4) access levels. Passcodes shall consist of up to ten (10) digits. Changes to passcodes shall only be made by authorized personnel. Systems not capable of password protected manual command operations shall provide key operated switches for these functions. Function key switches shall be keyed differently from any other keyed switches or locks used within the system.

2. The following keys/switches shall have access levels associated with them:
   - Alarm Silence
   - System Reset
   - Set Time/Date
   - Manual Control
   - On/Off/Auto Control
   - Disable/Enable
   - Clear Historical Alarm Log
   - Clear Historical Trouble Log
   - Walk Test
   - Change Alarm Verification

N. Detection Operation

1. Smoke sensors shall be smoke density measuring devices having no self contained alarm set point (fixed threshold). The alarm decision for each sensor shall be determined by the control panel. The control panel shall determine the condition of each sensor by comparing the sensor value to the stored values.

2. The control panel shall maintain a moving average of the sensors' smoke chamber value to automatically compensate (move the threshold) for dust and dirty conditions that could affect detection operations. The system shall automatically maintain a constant smoke obscuration sensitivity for each sensor (via the floating threshold) by compensating for environmental factors. The smoke obscuration sensitivity shall be adjustable to within 0.3% of either limit of the UL window (0.5% to 4.0%) to compensate for any environment.

3. The system shall automatically indicate when an individual sensor needs cleaning. When a sensor's average value reaches a predetermined value, a "DIRTY SENSOR" trouble condition shall be audibly and visually indicated at the control panel for the individual sensor. Additionally, the LED on the sensor base shall glow steady giving a visible indication at the sensor location. If a "DIRTY SENSOR" is left unattended, and its average value increases to a second predetermined value, an "EXCESSIVELY DIRTY SENSOR" trouble condition shall be indicated at the control panel for the individual sensor. To prevent false alarms, these "DIRTY" conditions shall in no way decrease the amount of smoke obscuration necessary for system activation. The control panel shall be listed to automatically perform the calibrated test requirements of NFPA 72.

4. The control panel shall continuously perform an automatic self-test routine on each sensor that will functionally check sensor electronics and ensure the accuracy of the values being transmitted to the control panel. Any sensor that fails this test shall indicate a "SELF TEST ABNORMAL" trouble condition with the sensor location at the control panel.

5. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each sensor:

   - primary status
   - device type
   - present average value
   - present sensitivity selected *
   - peak detection values *
   - sensor range (normal, dirty, etc.)

   *Values shall be in "percent of smoke obscuration" format so that no interpretation is required by the operator.

6. An operator at the control panel, having a proper access level, shall have the capability to manually control the following for each sensor:

   - clear peak detection values
   - enable or disable the point
   - clear verification tally
   - control a sensor's relay driver output

7. It shall be possible to program the control panel to automatically change the sensitivity settings of each sensor based on time-of-day and day-of-week (for example, to be more sensitive during unoccupied times and less sensitive during occupied periods). There shall be a minimum of five (5) sensitivity settings available for each sensor.

8. The control panel shall have the capability of being programmed for a pre-alarm or two-stage function. This function allows an indication to occur when, for example, a 3% sensor reaches a threshold of 1.5% smoke obscuration.

9. For increased smoke detection assurance, individually addressed smoke sensors shall be provided with alarm verification. Only a verified alarm shall initiate the alarm sequence operation.

O. RS-232-C Output

1. The Fire Alarm Control Panel shall be capable of operating remote printers. The output shall be paralleled ASCII from an EIA RS-232-C connection.

P. Digital Alarm Communication

1. Provide a digital communicator mounted in the FACU capable of transmitting an alarm to a remote central supervising station via two monitored telephone lines. The communicator shall supervise both telephone lines, seize the lines, and send a signal on one or both lines without the need of any additional equipment. If one line fails for more than 90 seconds, transfer to the remaining line occurs or if both lines fail, a local trouble alert signal sounds and an auxiliary relay contact alerts the BMS.

2. Provide a minimum of four (4) supervised channels, field configurable as either voltage inputs, active high or low inputs, or contact closure inputs programmed as follows:

a.	Channel 1	Alarm (Fire)
b.	Channel 2	Trouble (Fire)
c.	Channel 3	Sprinkler Supervisory
d.	Channel 4	Alarm (Fire Pump)

3. Provide an auto-test feature, 24-hour programmable, to a central station at a preset time including a manual test override and a ring detector for one call downloading/remote programming with remote PC software.

4. Provide 4-channel digital communicator by Silent Knight Model 5128 with Model 5230 LCD Annunciator/Keypad Programmer, Model 5561 Downloading Software/Modem Kit and Model TIK-512 Telephone Interface Kit, Edwards MODCOMP, Simplex Model 4100-0155 or approved equivalent.

Q. Building Management System (BMS)/Temperature Control System Interface

1. The FACU shall be capable of transmitting trouble and alarm signals to the Owner's BMS. Coordinate with Section 230923 and provide any interfaces, modules, or contacts to communicate with the BMS.

1.07 ALARM SEQUENCE

A. The system alarm operation subsequent to the alarm activation of any manual station, automatic detection device, or sprinkler flow switch is to be as follows:

1. Audible alarm notification appliances shall sound a non-coded digitized tone and voice message until silenced by the alarm silence switch at the control panel or remote annunciator panel(s).

2. Visual alarm notification appliances (xenon strobes) shall display a continuous pattern until extinguished by the Alarm Silence Switch.

3. Doors normally held open by door control devices shall release.

4. A supervised signal to notify an approved central station shall be activated. To accommodate and facilitate job site changes the type of "city connection circuit" is to be on site configurable to provide either a "reverse polarity", "local energy", "shunt" or dry contact connection.

5. Air handling systems (supply and return) larger than 2000 cfm, shall be automatically shutdown. Other systems and equipment shall also be shut down as indicated on the plans.

6. Alarms shall be displayed on the panel display. The alarm LED shall flash on the control panel until the alarm has been acknowledged at the control panel. Once acknowledged, this same LED shall latch on. A subsequent alarm received from another zone after acknowledged shall flash the alarm LED on the control panel and the panel display shall show the new alarm information. A pulsing alarm tone shall occur within the control panel and the remote annunciator until acknowledged.

7. Museums: Dry contact outputs from the fire alarm control panel (FACU) shall disable museum sound, projection and house lighting systems upon any alarm condition. Museum sound and projection systems shall be silenced and disabled to allow audiences to understand the alarm message. Museum lighting levels shall return to egress brightness for safe evacuation.

B. The activation of any carbon monoxide detector shall initiate an audible alarm distinctive from a fire alarm signal and shall comply with the following:

1. Interconnections to the fire alarm system shall be via supervisory circuits only.

2. Operation of carbon monoxide detectors shall not cause the fire alarm to activate central station fire alarm signals.

3. A fire alarm signal shall take precedence over any other signal, even when the carbon monoxide signal is initiated first.

4. Short circuits, open circuits or any ground fault in this equipment or interconnection between the equipment and the fire alarm shall not prevent alarm or trouble signal transmissions.

C. The control panel is to have a dedicated supervisory service LED and a dedicated supervisory service acknowledge switch.

1. The activation of any standpipe or sprinkler valve tamper switch shall activate the system supervisory service audible signal, illuminate the LED at the control panel and activate the electric sprinkler fire bell outside the building. Provide differentiation between valve tamper activation and opens and/or grounds on fire alarm initiation circuit wiring. Fire bells shall be furnished and installed by Section 210000 and wired by this contractor.

2. Activating the Supervisory Service Acknowledge Switch will silence the supervisory audible signal while maintaining the Supervisory Service LED on indicating the tamper contact is still in the off-normal state.

3. Restoring the valve to the normal position shall cause the Supervisory Service LED to extinguish thus indicating restoration to normal position.

D. Alarm and trouble conditions shall be immediately displayed on the control panel front alphanumeric display. If more alarms or troubles are in the system the operator may scroll to display new alarms.

E. The system shall have an alarm list key that will allow the operator to display alarms, troubles, and supervisory service conditions with the time of occurrence. This shall allow for the determination of not only the most recent alarm but also may indicate the path that the fire is taking.

F. The control panel shall be capable of supplying sufficient 24VDC power output to suit job conditions and expansion capability for system growth. Include a minimum of 20 percent spare capacity for 24 VDC notification appliance circuits.

1.08 SUPERVISION

A. The system shall contain a minimum of 2000 Class 'A' independently supervised initiation circuits so that a fault in any one zone shall not affect any other zone. The alarm activation of any initiation circuit shall not prevent the subsequent alarm operation of any other initiation circuit.

B. There shall be sprinkler supervisory initiation device circuits for connection of sprinkler valve tamper switches to perform the Supervisory Service Operation. Wiring methods which affect any fire alarm initiation circuits to perform this function shall be deemed unacceptable; i.e.: sprinkler and standpipe tamper switches (N/C contacts) shall NOT be connected to circuits with fire alarm initiation devices (N/O contacts). This independent initiation circuit shall be labeled Supervisory Service and shall differentiate between tamper switch activation and wiring faults.

C. Provide independently supervised and independently fused notification appliance circuits for audible alarms and flashing alarm lamps. A trouble condition of any circuit shall not affect the operation of other circuits.

D. Auxiliary manual controls shall be supervised so that switches must be returned to the normal automatic position to clear system trouble.

E. Each independently supervised circuit shall include a discrete panel readout to indicate trouble conditions per circuit.

F. The incoming power to the system shall be supervised so that any power failure must be audibly and visually indicated at the control panel. A green "power on" LED shall be displayed continuously while incoming power is present.

G. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visually indicated at the control panel.

H. The System Expansion Modules shall be electrically supervised for module placement. Should a module become disconnected from the controls, the system trouble indicator must illuminate and audible trouble signal must sound.

I. The system shall have provisions for disabling and enabling circuits individually for maintenance or testing purposes.

1.09 POWER REQUIREMENTS

A. The control panel shall receive 120 VAC emergency power (as noted on the plans) via dedicated fused cutout switch(es).

B. Speaker/Strobe Systems: During normal power failures, provide sufficient battery capacity to operate the entire system in a supervisory mode for a period of 24 hours with 15 minutes of entire system alarm operation at the end of this period. Systems shall meet these requirements, including those with an emergency generator. The system shall automatically transfer to the standby batteries upon power failure. Battery charging and recharging operations shall be automatic.

C. Circuits requiring system operating power shall be 24VDC and shall be individually fused at the control panel.

1.10 TRANSIENT & SURGE PROTECTION

A. Provide protection against voltage transients and surges as follows:

1. On AC Input: A feed-through (not a shunt-type) branch circuit transient arrestor such as the EFI HWM-120, Leviton OEM-120EFI, Northern Technologies TCS-HW, Transtector ACP100BWN3, or any approved equivalent UL Listed device. Install suppressor in a listed enclosure near the electrical panelboard, and trim excess lead lengths. Wind small coil in the branch circuit conductor just downstream of the suppressor connection. Coil to be 5 to 10 turns, about 1" diameter, and securely tie-wrapped. This series impedance will improve the effectiveness of the arrestor in suppressing voltage transients.

2. On DC Circuits Extending Outside Building: Adjacent to the FACU, and also near point of entry to outlying building, provide "pi"-type filter on each leg, consisting of a primary arrestor, series impedance, and a fast acting secondary arrestor that clamps at 30v-40v. Acceptable models: Innovative Technology D2S33-2ML, Simplex 2081-9027 and 2081-9028, Transtector TSP8601, Ditek DTKxLVL series, Citel America B280-24V, and Northern Technologies DLP-42 or approved equivalent. UL 497B listing is a prerequisite for consideration of alternative products. Devices using only MOV active elements are not acceptable.

1.11 ADDRESSABLE NETWORK

A. Communication with addressable devices: The system must provide communication with initiating and control devices individually. These devices are to be individually annunciated at the control panel. Annunciation shall include the following conditions for each point:

1.	Alarm	4.	Short
2.	Trouble	5.	Ground
3.	Open	6.	Device Fail/or Incorrect Device

B. Addressable devices are to have the capability of being disabled or enabled individually.

C. Up to 60 addressable devices may be connected to a single pair of wires. Systems that require factory reprogramming to add or delete devices are unacceptable.

D. Format: The communication format must be a poll/response protocol to allow t-tapping of the wire to addressable devices and be completely digital. A high degree of communication reliability must be obtained by using parity data bit error checking routines for address codes and check sum routines for the data transmission protocol. Systems that do not utilize full digital transmission protocol (i.e. that may use time pulse width methods to transmit data etc.) will not be acceptable since they are considered unreliable and prone to errors.

E. Identification of Addressable Devices: Each addressable device must be uniquely identified by an address code digitally entered on each device at time of installation. The use of jumpers to set address will not be acceptable due to the potential of vibration and poor contact.

F. Wiring Type, Distances, Survivability and Configurations: Wiring types will be approved by the equipment manufacturer. The system must allow up to 2,500 feet wire length to the furthest addressable device. Provide Class A signaling line circuits as defined by NFPA-72 for initiation with no “T” taps and Class A for notification appliance circuits with no “T” taps. The load connected to each notification appliance circuit shall not exceed 80% of rated module output. The voltage drop during alarm must not exceed 14% of the voltage measured across the batteries at that time. To achieve this, the installation shall consider wire size, length of circuit, device load, inherent voltage loss within the FACU's power supply, etc. The contractor shall use power outage testing to verify that the NAC circuit was designed and installed properly.

G. For installations, where data/communication loops will run underground outdoors between buildings, provide manufacturer’s recommended lightning

surge suppression devices for each associated data loop. Locate devices at each point where loop(s) enters building(s) to protect associated system electronics.

1.12 ONE-WAY VOICE COMMUNICATION

A. The system shall incorporate one-way voice communication and tone generating capabilities. Audio amplifiers and tone generating equipment shall be electrically supervised for normal and abnormal conditions. Provide two (2) amplifiers minimum and connect speakers to alternate circuits and arrange control equipment such that a loss of a portion of the wiring on a floor will not render more than 60% of the devices of each type inoperative, and the devices shall remain so connected to circuitry (i.e. by means of alternate circuits) as to maintain at least partial audibility/visibility throughout the entire floor.

B. A central audio control module shall be provided for the necessary alarm message/tone generation, main and remote microphone connections, music inputs, and mixer/pre-amplifier circuits. Continuous supervision shall be provided along with specific information as to the type of failure should a problem occur (i.e. main microphone trouble, tone trouble, etc.). Audio outputs shall have individual gain control.

C. A hand-held, push-to-talk microphone shall be provided, recessed within a protective panel-mounted enclosure. The microphone shall be a noise-canceling communication type with a frequency range of 200 Hz to 4000 Hz and shall be equipped with a self-winding five foot coiled cable. An LED indicator shall be provided to indicate the microphone push-to-talk button has been pressed and speaker circuits are ready for transmission. The microphone shall be supervised for disconnection.

D. An audio control switch module shall be furnished to provide manual access to audio operations for authorized personnel. The module shall include an "ALL Circuits" switch, "Aux Tone 1" switch, "Aux Tone 2" switch, tone generator stop switch, and "Audio Trouble Reset" switch. These switches and associated LED indicators shall be supervised for trouble or failure.

E. Audio power amplifiers shall be furnished with a self-contained filtered 24VDC power supply, transformer, and amplifier monitor circuits. The amplifiers shall provide a 25 Volt or 70 Volt RMS output with a frequency response of 120 Hz to 12,000 Hz. Provide sufficient amplification to operate system speakers simultaneously plus ten (10) percent spare capacity. Size amplifiers based on 2 watts minimum per speaker with 100% of speakers adjusted to the 2 watt tap setting.

F. Provide remote microphone/annunciator command sub-systems as shown on the plans shall to duplicate the manual voice transmission capability of the main

fire alarm control panel. The sub-system microphone shall communicate only to the respective area speakers. The main FACU microphone shall override sub-system voice evacuation microphones and transmit the message throughout the main system and sub systems.

G. Automatic Voice Evacuation Sequence

1. The audio alarm signal shall consist of an alarm tone for a maximum of 15 seconds followed by automatic pre-selected voice evacuation messages. At the end of each voice evacuation message, the alarm tone shall resume. The alarm tones shall sound alternately until the alarm silence switch at the fire alarm control panel has been operated.

2. Audio alarm operations (speaker circuit selection and alarm tone/voice message timing variations) shall be activated by the system software so that any required future changes to the evacuation sequence can be facilitated by authorized personnel without any component rewiring.

H. Voice Evacuation Zones

1. Provide a minimum of two (2) independent audio circuits from independent amplifiers to each voice evacuation zone as scheduled on the drawings.

2. Each floor, stairway, and assembly space (>300 persons) shall be a separate communication zone.

3. Strobe lights shall not be installed in stairways or photo darkrooms.

PART 2 - PRODUCTS

2.01 FIRE ALARM CONTROL UNIT (FACU)

A. Subject to compliance with requirements, provide Fire Alarm Control Units manufactured by one of the following:

1. Siemens Fire Safety Model XLSV FireFinder
2. Tyco Simplex-Grinnell Model 4100U Voice
3. UTC Fire & Security/Edwards Model EST 3 Audio
4. Honeywell Notifier Model NFS-3030
5. Honeywell Gamewell-FCI E3 Series Broadband

B. Construction shall be modular with solid state, microprocessor based electronics. The FACU shall display only those primary controls and displays essential to operation during a fire alarm condition. Although the

keypad/keyboard can be used for control (firefighter/emergency) of the entire system, it shall only be used for maintenance purposes. Keyboards or keypads shall not be visible or required to operate the system during fire alarm conditions.

A local audible device shall sound during Alarm, Trouble, or Supervisory conditions. This audible device shall sound differently during each condition to distinguish one condition from another without having to view the panel. This audible device shall also sound differently during each keypress to provide an audible feedback (chirp) to ensure that the key has been pressed properly.

C. Primary Keys & Panel Display

The Control Panel's display shall be backlit for enhanced readability. So as to conserve battery standby power, it shall not be lit during an AC power failure unless an alarm condition occurs or there should be keypad activity. The display shall support both upper and lower case letters. Lowercase letters shall be used for softkey titles and prompting the user. Uppercase letters shall be used for System Status Information. A cursor shall be visible when entering information. The display shall include a back-lit alphanumeric Liquid Crystal Display (LCD). It shall include LED indications for Pwr, Test, CPU Fail, Grnd. Fault, Disable, Reset, Alarm Silence, Panel Silence, Drill, as well as individual Ques for alarm, trouble, supervisory, and monitor events.

D. Equipment Enclosures

Provide cabinet(s) of sufficient size to accommodate the aforementioned equipment. The cabinet(s) shall be equipped with locks and transparent door panel(s) providing freedom from tampering yet allowing full view of the various lights and controls. Provide a separate enclosure for batteries larger than 15 ah. Enclosures shall be flush or semi-flush mounting unless otherwise indicated on the drawings.

2.02 PERIPHERAL DEVICES

A. Evacuation Signals, Voice Reproducing
Voice reproducing and visual alarm signals shall meet Americans with Disabilities Act (ADA) and UL Standard 1971 requirements shall have the following characteristics and capacities with provisions for speaker only and strobe only installations as required:

1. Field selectable taps at 3db increments between 1/8 watt and 8 watts, driven at 25 volts rms or 70 volts rms, as shown on the drawings.

2. Sound output rating of 96 db at full power tap.

3. Visual intensity: Field-selectable 15/30/75/110 or 135/185 candela for wall-mounted units; field-selectable 15/30/75/95 or 115/177 candela for ceiling-mounted units; xenon strobe, synchronized repetition of 1-3 Hz, 0.2 second pulse duration, clear white light (FIRE), white color housing, and back box. The LEXAN lens shall be pyramidal in shape to allow better visibility, labeled "FIRE" complying with ADA guidelines.

4. Signals to be suitable for installation in audible only, audible/visual, and visual only in combinations described above and below:

   a. Wheelock ET-Series; Siemens S-HP series; Notifier SpectrAlert SP2 series; System Sensor SpectrAlert series; Simplex TrueAlert 4906 series; Edwards Genesis series. Provide mounting (wall and/or ceiling) as required by plans. Flush mount with 4-inch square outlet boxes; surface mount with manufacturer's factory finished backbox. Set candela ratings as indicated on plans. Appliances and associated wall plates shall be white.

   b. Concealed Series: Provide recessed and concealed notification appliances (wall or ceiling) as required by plans. Concealite FA900 series (wall) or FAFX (ceiling), color: white.

5. Unless otherwise indicated on the drawings, alarm speaker taps shall be set, as a minimum, to provide the following wattage levels for each location type of alarm speaker:

   a. Each floor alarm speaker: Provide 1 watt of input power.

   b. Each toilet alarm speaker: Provide 1/2 watt of input power.

   c. Each mechanical room alarm speaker: Provide 2 watts of input power.

B. Waterflow Alarm Bells – Furnished under Section 21000; power supply and installation and connection by this contractor.

C. Door Holders: Magnetic door holders shall have a minimum holding force of 25 lbs. The door portion shall have an adjustable stainless steel pivotal mounted armature and contact plate with shock absorbing nylon bearing. Unit shall be capable of being either surface, flush, semi-flush or floor mounted as required. Door holders shall be UL-listed for their intended purpose. Operation: 24 volts unless indicated as 120 volts on drawings. Siemens Model

SDH series, Edwards 1500 series, Notifier FM series, Simplex 2088 series, Gamewell DH series or approved equivalent. Coordinate final locations and hardware with Architect.

2.03 ADDRESSABLE DEVICE TYPES

A. General

The system control panel, over its two wire multi-drop channel, must be capable of communicating with the types of addressable devices specified below. Each device shall be electronically addressed, tested and programmed prior to installation using a UL-listed programmer/tester. Detectors shall be operational with relay bases, audible bases, and remote indicating LED's and programmable by the control panel. Devices shall be located as shown on the drawings. Devices shall be electronically addressed and not require mechanical means of setting individual address's for ease of service and replacement.

B. Smoke Detector, Photoelectric: Pulsed infrared light source, photodiode, self-compensating for ambient temperature and humidity, in-place sensitivity readout from the control panel, two wire operation, dual LED alarm indication for 360° viewing angle, UL (UROX) Listed for open area coverage. Include sounder base for sleeping room installations. Notifier FSP series, Siemens Fire Safety FP-11 FirePrint series, Edwards Signature series, Simplex 4098-9714, Gamewell Velociti series or approved equal.

C. Smoke Detector, Photoelectric, Duct Mounted: Analog HVAC duct smoke detectors listed for installation in air duct sampling housings for the detection of smoke in HVAC system ducts, with RF suppression and insect screen. Auxiliary SPDT relays or remote LED alarm indicators shall be installed where indicated. Provide remote LED alarm indicators and test stations in accessible locations for duct detectors. Notifier FSD series, Siemens Fire Safety AD-11XPR housing and Series 11 intelligent detector, Edwards Signature series, Gamewell Velociti series or approved equal.

D. Smoke Detector, Beam: Modulated infrared projected beam type with reflector; field selectable for sensitivities of 20, 35, or 60 percent obscuration, LED alarm indication on receiver, self-compensation for accumulation of dust and aging, internal tamper switch for cover removal, two wire operation and 15,000 square foot coverage. Include key locked remote test and reset station for each beam detector. System Sensor Beam 1224 Series with RTS451 Remote Test Station w/key lock, Honeywell Notifier 1224 Series, Siemens Fire Safety PBA-1191, UTC Fire & Security/Edwards EC-50R/100R, Simplex-Grinnell, Gamewell Velociti series or approved equal.

E. Heat Detector, Rate Compensated: Combination fixed temperature (135°F) and rate of rise, LED alarm indication, automatically restorable, 900 square foot coverage. Provide higher fixed-temperature-only, 200°F rated detectors where indicated on plans. Edwards Signature series, Siemens Fire Safety FPT-11 (for 135°F) or DT-200F (for 200°F), each with addressable CZM interface, Notifier FST series, Simplex 4098-9733 (for 135°F) or 2098-9442 (for 200°F), Gamewell Velociti series or approved equal.

F. Fire Detector Bases, Universal: Low profile twist lock type with screw clamp terminals and self-wiping contacts, with EMI and RFI immunization. Bases shall be installed on 4" square or octagonal electrical outlet box. Where selective localized control of electrical devices is required for system operation, provide software programmed addressable relay integral to the base. The relay shall switch electrical loads, as indicated on the drawings for controlled release of smoke hatches and shaft vents. Detector bases shall be compatible with, and allow the installation of, detectors operating on the flame, ionization, photoelectric, or rate compensated heat principles of detection. Siemens Fire Safety DB-11 and DB-X11RS, Simplex 4098-9792, Edwards SIGA-SB, Notifier B224RB or approved equal.

G. Carbon Monoxide Detector: Low profile solid state sensor with hard-wired SPDT trouble and alarm relays, buzzer and visual status indicator, 24 VAC/DC, Macurco Model CM-15/15A, System Sensor CO1224T or approved equal. Provide system interface module to provide addressable interface with FACU and auxiliary power supply as required.

H. Manual Station: Double action and identifiable by the master fire alarm control panel. Manufactured from high impact red Lexan with white raised lettering, mechanical latch upon operation, FACU-key operated manual reset. Flush or surface mounted as required, include manufacturer's back box, red baked enamel finish. Siemens Fire Safety MSI-20, Edwards Model SIGA series, Simplex 2099 series, Notifier NBG-12, Gamewell Velociti series or approved equal. [Manual stations shall be furnished with a tamper proof, clear Lexan polycarbonate shield and frame where indicated. An integral battery powered warning horn shall sound when shield is lifted. STI #STI-1000 series or approved equal.

I. Remote Zone Module: Zone modules shall be used to interface normally open direct contact (non-addressable) devices to an addressable signaling line circuit. The module shall be identifiable by the master fire alarm control panel and contain an on board LED alarm indicator. Mounting: standard 4-inch outlet box, flush, surface and weatherproof as shown for the area indicated.

J. System Interface Module: Interface modules shall be used to interface normally open direct contact non-addressable devices to an addressable signaling line circuit to monitor alarm, trouble, supervisory or security devices. The module shall have Form C programmable control contacts for the management of specified electrical loads as shown on the drawings. The module shall be identifiable by the master fire alarm control panel and contain an on board LED alarm indicator. Mounting: standard 4-inch outlet box, flush, surface and weatherproof as shown for the area indicated. Siemens Fire Safety TRI-B6 series, Simplex 4090-9001 or 4090-9101, Notifier FMM-1, Edwards Signature series, Gamewell Velociti series or approved equal.

K. Supervised Control Module: Control modules shall be used to supervise relays, contactors, audible signal circuits, visual signal circuits, distributed speaker circuits and two way fire fighters communication circuits. Controlled circuits shall be power limited at 1.5 amperes. The module shall be identifiable by the master fire alarm control panel and contain an on board LED alarm indicator. Mounting: standard 4-inch x 2-inch deep or double gang x 3-inch deep outlet box, semi-flush or surface.

L. Controllable Relay Module: Controllable relay modules shall be used to provide auxiliary control of building functions such as door holder release, smoke control, lock release, shunt trip, etc. Each relay shall be supervised and include one set of SPDT contacts rated at 2 amperes, 30 VDC/120 VAC resistive minimum. Siemens Fire Safety CRM-4, Edwards Signature series, Simplex 2190-9173, Notifier FCM-1 series, Gamewell Velociti series or approved equal.

M. Control Relay: Provide remote relays where required for relay contact requirements above the approved rating of addressable relay modules for remote control of fans, dampers, door releases, motor controls, or status feedback. Relay shall be SPDT contacts rated at 10 amperes, 24 VDC/115VAC. A red LED shall indicate the relay is energized. PAM series or approved equal.

2.04 AIR SAMPLING SMOKE DETECTION SYSTEM - GENERAL

A. Design Requirements - Air Sampling Smoke Detection System

1. Shall consist of a highly sensitive LASER-based smoke detector, aspirator, and filter.

2. The detection unit shall also include a scanning valve mechanism to identify which sampling pipe is carrying smoke.

3. It shall be modular, with each detector optionally monitored by a Display featuring LED's and a sounder. The system shall be configured by a Programmer that is either integral to the system, portable or PC based.

   The system shall allow programming of:

   - four smoke threshold alarm levels per pipe (sector);
   - time delays;
   - faults including airflow, detector, power, filter and network as well as an indication of the urgency of the fault;
   - seven or twelve configurable relay outputs for remote indication of alarm and fault conditions.

4. It shall consist of an air sampling pipe network to transport air to the detection system, supported by calculations from a computer-based design modeling tool.

5. Optional equipment may include intelligent remote displays and/or a high level interface with the building fire alarm system, or a dedicated VESDA System Management (VSM) graphics package.

B. Performance Requirements

- Shall be tested and approved to cover up to 20,000 sq. ft.
- Shall be approved to provide very early smoke detection and provide four output levels corresponding to Alert, Action, Fire 1 and Fire 2 per pipe (sector). These levels shall be programmable and able to be set at sensitivities ranging from 0.0015–6% obsc/ft. For compliance to UL approval range is 0.0015-4% obsc/ft.
- Shall report any fault on the unit by using configurable fault output relays or via VSM.
- Shall be self monitoring for filter contamination. Shall incorporate a flow sensor in each pipe and provide staged airflow faults.

2.05 AIR SAMPLING SMOKE DETECTION SYSTEM

A. Aspirating Smoke Detection System: Model – VESDA SCANNER.

B. Acceptable Manufacturer:

Vision Fire & Security – VESDA
700 Longwater Drive
Norwell, MA 02061
Toll Free: 1 800 229 4434
Telephone: +1 781 740 2223
Fax: +1 781 740 4433
Website: www.vesda,com

C. Detector Assembly

1. The Detector, Filter, Aspirator and Relay Outputs shall be housed in a mounting box and shall be arranged in such a way that air is drawn from the fire risk and a sample passed through the Dual Stage Filter and Detector by the Aspirator.

2. The detection unit shall also include a scanning valve mechanism to identify which sampling pipe is carrying smoke

3. The valve mechanism shall:

- be integrated into the detector
- begin to sample each pipe individually upon detection of smoke
- be used to identify the level of smoke in each pipe
- be used to indicate in which pipe an alarm was first detected
- operate upon manual activation of the scan button on the LaserSCANNER display
- be automatically tested daily to ensure uninterrupted protection

4. The system shall utilize the principle of sampling all sectors simultaneously. When a scan smoke level is reached, an automatic sequence shall be initiated to sample each sector individually. If an alarm threshold level is reached a First Alarm Sector is indicated and signaled. The unit shall then continue its sequence monitoring until the smoke level signal reduces below the scan level.

5. The Detector shall be LASER-based type and shall have an obscuration sensitivity range of 0.0015%/ft – 6% obs/ft.

6. The Detector shall have four independent field programmable smoke alarm thresholds per pipe (sector) and a programmable scan time delay.

7. The Detector shall also incorporate facilities to transmit the following faults

   - Detector
   - Air flow
   - Filter
   - System
   - Zone
   - Network
   - Power
   - Urgent and Minor faults. Minor faults shall be considered as servicing or maintenance signals. Urgent faults indicate the unit may not be able to detect smoke.

8. The detector shall have four in-line sample pipe inlets and must contain a flow sensor for each pipe inlet. Both Minor and Urgent flow faults can be reported.

9. The filter must be a two-stage disposable filter cartridge. The first stage shall be capable of filtering particles in excess of 20 microns from the air sample. The second stage shall be ultra- fine, removing more than 99% of contaminant particles of 0.3microns or larger, to provide a clean air barrier around the detector's optics to prevent contamination and increase service life.

10. The aspirator shall be a purpose-designed rotary vane air pump. It shall be capable of allowing for multiple sampling pipe runs up to 600 ft. in total, (4 pipe runs per detector) with a transport time of less than 120 seconds or as appropriate codes dictate.

11. The Assembly must contain relays for alarm and fault conditions. The relays shall be software programmable to the required functions. The relays must be rated at 2 AMP at 30 VDC. Remote relays shall be offered as an option and either configured to replicate those on the detector or programmed differently.

12. The Assembly shall be able to be surface mounted to a wall or recessed in the wall cavity (the unit may be inverted in either option).

13. The assembly shall have built-in event and smoke logging. It shall store smoke levels, alarm conditions, operator actions and faults. The date and time of each even shall be recorded. Each detector (zone) shall be capable of storing up to 18,000 events and does not require the presence of a display in order to do so.

14. Displays

a. When required, a detector Display module may be located within the detector, a remote mounting box or a 19 inch remote rack.

b. Each Display shall provide the following features at a minimum:

- A 20 segment bargraph display.
- Four independent high intensity alarm indicators, Alert, Action, Fire 1 and Fire2, corresponding to the four alarm thresholds of the indicated sector.
- Alarm threshold indicators for Alert, Action and Fire 1.
- LED indication that the First Alarm Sector is established
- LED indication of which pipe(s) is carrying smoke
- Detector fault and airflow fault indicators.
- Faults originating in the particular VLS zone (Zone Fault) shall be distinguished from those produced by the overall smoke detection system and from those resulting from network wiring errors (Network Fault). LED indicators shall be provided for each fault category.
- Minor and urgent fault LED indicators.
- A remotely mounted Display may be optionally equipped with 7 or 12 configurable relays for signaling alarm and fault conditions.
- Four buttons supporting the following features:

1) Mode/Test - Scrolls through the information on the Display's digital display: Sensitivity (Fire 1 Threshold setting), current smoke level, VLS Zone number and First Alarm Sector. When pressed and held initiates a lamp test on the individual display module.
2) Silence/Scan - Silences all devices on the system. When pressed and held initiates a manual scan test.
3) Reset - Unlatches all latched alarm conditions on the assigned VLS zone.
4) Isolate – Isolates the individual VLS zone (inhibits Alarm and Fault relays and initiates the Isolate relay).

15. Programmers

a. When required, a Programmer module may be located within the detector, a remote mounting box, a 19 inch remote rack, or in a portable hand-held unit. Alternatively, programming may be performed using a Windows® application running on a PC

connected through a High Level Interfacing unit (PC-Link HLI).

b. Each Programmer shall support the following features at a minimum:

- Programming of any device on the VESDAnet system.
- Viewing of the status of any device in the system.
- Adjustment of relative alarm thresholds for each pipe (sector factor)
- Adjustment of period of sampling for each pipe
- Software configuration for either 7 or 12 relays
- Setting of Day/night, weekend and holiday sensitivity threshold settings.
- Initiation of AutoLearn™, to automatically configure the detector's alarm threshold settings to suit the current environment.
- Multi-level password control.
- Programmable latching or non-latching relay operation.
- Programmable energized or de-energized relays.
- Programmable high and low flow settings for airflow supervision.
- Programmable aspirator speed control.
- Programmable maintenance intervals.
- Facilities for referencing with time dilution compensation.
- Testing of relays assigned to a specific zone to aid commissioning.

16. Device Networking Requirements

a. The devices in the smoke detection system shall be capable of communicating with each other via twisted pair RS485 cable. The network shall be able to support up to 250 devices (detectors, displays and programmers), of which at least 100 detectors can be supported.

b. The network shall be capable of being configured in a fault tolerant loop for both short circuit and open circuit. Any communication faults shall be reported unambiguously and shall be clearly attributable to an individual device or wire link in the fault messages.

c. PC based configuration tools shall be available to configure and manage the network of detectors.

17. Digital Communication Port: Shall comply with EIA RS485 Protocol.

18. Application

a. Detection Alarm Levels

The laser based aspirating detection system shall have four (4) alarm thresholds per pipe (sector). The four alarm levels may be used as follows:

- Alarm Level 1 (Alert)
  Activate a visual and audible alarm in the fire risk area.
- Alarm Level 2 (Action)
  Activate the electrical/electronic equipment shutdown relay and activate visual and audible alarms in the Security Office or other appropriate location.
- Alarm Level 3 (Fire 1)
  Activate an alarm condition in the Fire Alarm Control Panel to call the Fire Brigade and activate all warning systems.
- Alarm Level 4 (Fire 2)

Activate evacuation action or shut down of systems).

NOTE: The alarm level functions as listed are possible scenarios. Consideration should be given to the best utilization of these facilities for each application and the requirements of local authorities (e.g. Authorities Having Jurisdiction in the US).

b. Initial Detection Alarm Settings

Initial settings for the alarm levels shall be determined by the requirements of the fire zone. However, the setting for Fire 1 (Alarm Level 3) shall always appear as 100% on the bargraph scale. Default settings of the unit shall be:

- Alarm Level 1 (Alert) 0.025% Obs/ft
- Alarm Level 2 (Action) 0.044% Obs/ft
- Alarm Level 3 (Fire 1) 0.062% Obs/ft
- Alarm Level 4 (Fire 2) 0.61% Obs/ft

Each pipe shall have its alarm thresholds set by a Sector Factor. The Sector Factor range shall be between 0.5 and 2.0 (where 2.0 doubles the normal alarm threshold settings).

c. Initial (factory default) Delays

Initial (factory default) settings:
- Scan Delay 10 seconds
- Fault Alarm 5 seconds

d. Fault Alarms

The Detector Fault relay shall be connected to the appropriate alarm zone on the Fire Alarm Control Panel in such a way that a Detector Fault would register a fault condition on the FACP. The Minor Fault and Isolate relays shall also be connected to the appropriate control system.
(Check local Codes, Standards or Regulations to determine whether compliance with this set-up is required).

e. Power Supply and Batteries

The system shall be powered from a regulated supply of nominally 24V DC. The battery charger and battery shall comply with the relevant Codes, Standards or Regulations. Typically 24 hours standby battery backup is required followed by 30 minutes in an alarm condition.

Local Power Supply Standards that may apply:
UL 1481 Listed (provided the power supply and standby batteries have been
appropriately sized/rated to accommodate the system's power requirements).

2.06 AIR SAMPLING PIPE DESIGN

A. Sampling Pipe

1. The sampling pipe shall be Vesda Pipe ¾-inch internal diameter CPVC Piping, Listed to UL 1887 (which includes use in plenum rated areas).

2. All joints in the sampling pipe must be air tight and made by using solvent cement, except at entry to the detector.

3. The pipe shall be identified as Aspirating Smoke Detector Pipe (or similar wording) along its entire length at regular intervals not exceeding the manufacturer's recommendation or that of local codes and standards.

4. All pipes should be supported at not less than 5ft centers, or that of the local codes or standards.

5. The far end of each trunk or branch pipe shall be fitted with an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

B. Sampling Holes

1. Sampling holes of 5/64", or otherwise appropriately sized holes (see Section 3.05), shall not be separated by more than the maximum distance allowable for conventional point detectors as specified in the local code or standard. Intervals may vary according to calculations.

2. N.F.P.A. 72 (1996 Edition) the maximum allowable distance between sample points is 30 feet.

C. Each sampling point shall be identified in accordance with Codes or Standards.

D. Consideration shall be given to the manufacturer's recommendations and standards in relation to the number of Sampling Points and the distance of the Sampling Points from the ceiling or roof structure and forced ventilation systems.

2.07 REMOTE ALPHANUMERIC ANNUNCIATORS

A. Where shown on the plans, provide supervised, remote alphanumeric annunciators with features and characteristics as follows:

1. Any activity supported at the main control panel shall be enabled at the remote annunciator.

2. Active poll response communications with the master fire alarm control panel using the local system communications network.

3. Minimum 80 character alphanumeric display for fire alarms, supervisory reports, and system troubles. The number of characters shall mimic the number of characters on the main panel display.

4. Individual fire alarm, supervisory, security and trouble acknowledge momentary switches and power "ON", each with LED indicators showing acknowledgement status by flashing and steady states.

5. Remote paging capability consisting of dynamic push to talk microphone with enclosure.

6. Scroll switch for the alarm display. Switch shall enable scrolling backward or forward through the alarm queue.

7. Integral audible signal with audible signaling silence switch with LED indicating the state of the evacuation signals.

8. Key menu driven keypad for the entry of passcodes, request for reports, setting time, and bypassing points.

9. Twelve software programmable function key commands. These commands shall be capable of utilizing any and system logic functions resident within the system programming or of being an input into any of the logic functions.

10. Locked cabinet, factory finished enamel with viewing window. Cabinet shall not exceed 14 inches in width and height, or 3.5 inches in depth.

11. The annunciator shall be capable of supporting a supervised system printer, system CRT control terminal with keyboard or system color graphics alarm display terminal.

12. Remote annunciator shall be Siemens Fire Safety remote command center #RCC series or Edwards LSRA-C or 3-LCDANN series, Notifier FDU 80 series, or Simplex 4603-9101 or approved equal.

2.08 DESKTOP PRINTER

A. Desktop printer shall be standard carriage, 80 characters per line, serial or parallel interface, supervised circuitry, UL listed, using standard pin-feed paper. Enclosure shall be suitable for placement on a desk or tabletop. Printer shall operate on 120 VAC.

B. Provide necessary interconnecting cables, connectors, and interfaces.

C. The printer shall automatically provide a hard-copy printout of changes in system status, indicating the time, date, location, device identification, and type of occurrence.

2.09 WIRING

A. Fire alarm cable shall be "Teflon" jacketed, or the equivalent, conforming with the requirements for type FPLP "Power-Limited Fire Protective-Signaling Circuits," having a temperature rating of 60^{o}C or higher, solid conductor insulation with a minimum average thickness of 7 mils, protected with a sheath and an outer jacket of 15 mils minimum, colored red. Cable shall be labeled for its entire length per UL 1424, size, voltage, and temperature rating.

B. Provide and install two #14 AWG minimum twisted pair, shielded for initiating device analog loop circuits.

C. Provide and install two #14 AWG minimum twisted pair, shielded for strobes, and non-shielded for speakers and analog audible device loop circuits.

D. Provide and install two #14 AWG minimum twisted pair, non-shielded for each waterflow alarm bell.

E. Verify conductor sizes and quantities with system manufacturer, prior to installation.

F. Increase wire size to accommodate voltage drop per manufacturer's recommendations. Design circuits to a maximum of 75% rated capacity to accommodate future device additions and sound level changes. Do not exceed manufacturer's maximum circuit lengths.

G. Provide permanent wire markers to identify connections at the FACU and other control equipment, at power supplies, and in terminal cabinets.

H. Notification appliance circuit booster ("ADA") power supplies shall be individually monitored by the FACU and protected by a smoke detector per NFPA 72. Do not locate above ceilings or in non-conditioned space. Note: A 24VDC power circuit service addressable control relays shall also be monitored for integrity.

2.10 ISOLATOR MODULE

A. Provide isolator modules to automatically isolate wire-to-wire short circuits on a signaling line circuit (SLC) loop at termination of circuit unless built-in to FACU. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop after each 25 initiating devices and control points or a lesser number where recommended by the manufacturer. Modules must be readily accessible (not above ceiling) and clearly labeled.

B. Operation: Isolator modules shall operate such that if a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section. The isolator module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.

C. Mounting: The isolator module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

D. Labeling: Each isolation module must be clearly labeled, readily accessible for convenient inspection (not above a lay-in ceiling), and shown on "as-built" record system drawings.

2.11 SPARE PARTS

A. Spare parts shall be directly interchangeable with the corresponding components of the installed system. Spare parts shall be suitably packaged and identified by nameplate, stamping or tagging. Furnish the following spare parts, in the quantities listed:

Automatic Detectors of each type installed: [5]
Manual pull stations: [2]
Fire alarm notification devices of each type: [5]
Fuses for each fused circuit: [10]
Lamps for each lamp type furnished: [10]
Sets of keys, wrenches or special tools required to gain access to lockable equipment: [5]

B. In addition to the above, the FACU shall have sufficient internal space for the future addition of at least 5 additional multiplex loop cards and associated power supplies, hardware, etc.

PART 3 - EXECUTION

3.01 DESIGN AND INSTALLATION DRAWINGS

A. Show a general layout of the complete system including equipment arrangement. Verify dimensions and assure compatibility with other systems interfacing with the fire alarm system.

1. Identify on the drawings, conduit and conductor sizes and types with number of conductors in each conduit. Provide each conduit and device with a unique identification.

2. For addressable alarm initiation devices, the system identifier shall be, as minimum, the system address for that device. Signals shall be sequentially numbered as the address of the controlling module. Provide additional identification labels, room name, number and area,

etc., as required by the Owner and coordinated with the Owner prior to final programming of the FACU.

3. Indicate on the point to point wiring diagrams, interconnecting wiring within the panel between modules, and connecting wiring to the field device terminals.

3.02 INSTALLATION

A. Field installer shall be NICET Level 3 certified in Fire Protection Engineering Technology, Fire Alarm Systems. Perform work in accordance with the requirements of NFPA 70, NFPA 72, and other requirements of local authority having jurisdiction.

B. Fasten equipment to structural members of building or metal supports attached to structure, or to concrete surfaces.

1. Use clamping devices for attaching to structural steel, or when clamping is impractical, obtain written authority to weld or to drill.

2. Fasten equipment to concrete or masonry with expansion anchors.

3. Fasten equipment to drywall by screws into studs, and to metal wall panels by weld studs, bolts or self-tapping metal screws.

4. Do not install conduit raceways and boxes in positions that interfere with the work of other trades.

5. Attach nameplates on panels or other components as specified.

C. Install equipment and devices where indicated; refer to architectural drawings for exact locations and mounting heights.

D. Refer to HVAC drawings and specifications (Division 23) for exact locations of duct-mounted smoke detectors. Coordinate with appropriate trade for the cutting of ducts and mounting of housings and sampling tubes.

E. Provide remote indicators for concealed smoke detectors and install in a readily visible location as close as possible to the location of the associated detector, either flush wall mounted 5'-0" AFF, or flush ceiling mounted. Provide remote indicators for duct smoke detectors located outside of mechanical equipment rooms. Coordinate exact mounting locations of remote indicators with architect in field.

F. Smoke detectors shall not be located in a direct air flow nor be closer than three (3) feet from an air supply diffuser or return air opening. Increase separation as required per NFPA 72.

G. Provide a separate raceway system for fire alarm wiring. Power shall not be installed in raceways with low voltage wiring. Raceway shall be electrical metallic tubing (EMT), minimum ¾-inch size, maximum 40% fill and as indicated on drawings. Refer to Section 260500 for raceway and installation requirements.

H. Unless otherwise indicated, backboxes shall be recessed, and conduits and cable shall be concealed.

I. "Fire alarm system" decal shall be applied to junction box covers. Junction box covers shall be painted “fire department red”.

J. Each conductor shall be identified with wire markers at every splice and terminal point. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.

K. Splices shall not be made other than at terminal blocks or on terminal blocks at cabinets. Wire nuts and crimp splices shall not be permitted. Connectors shall be installed in conformance with the manufacturer's recommendations.

L. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

M. Permanently label or mark each conductor at both ends with permanent alpha-numeric wire markers.

N. Use a consistent color code for fire alarm system conductors throughout the installation.

O. Smoke detectors shall not be installed until final construction clean-up has been completed. Replace detectors contaminated during construction. Caution: Covers supplied with smoke detector head do not provide protection against heavy construction dust, spray painting, etc., and shall not be used for that purpose. Covers are suitable only during final, minor clean-up or touch-up operations.

P. The contractor shall clean dirt and debris from the inside and the outside of the fire alarm equipment after completion of the installation.

Q. The manufacturer's authorized representative shall provide on-site supervision of installation. Power shall not be applied to the system until a manufacturer's factory trained representative is present.

R. Identify individual devices. Assign each a unique number as follows, in sequence starting at the FACU: (Addressable Loop # -- Device # -- Room/Space #). Show on the record drawings, and also permanently mount on each device's base so that the identification is readable standing on the floor below without having to remove the device. Exception: For detectors with housings (air duct, projected beam, air sampling) apply the identification to a suitable location on the exterior of the device housing. Addressable device descriptors shall utilize room/space designations and numbers that will be used by the facility after occupancy. Descriptors shall be approved by the architect.

S. For each duct/plenum detector provide remote alarm indicator lamp/test switch installed in the nearest corridor or as shown on plans. Identify each location by an engraved label affixed to the wall or ceiling.

T. The contractor shall provide up to three fire alarm system reprogramming revisions as directed by the Owner.

U. Provide supervisory alarm wiring from the fire pump controller to the fire alarm system. Supervisory alarms to be wired are: power failure alarm, phase reversal alarm, and pump running alarm. Coordinate all alarm contact voltages, ratings, and types (NO/NC) with the equipment being supplied.

V. The fire alarm voice evacuation system messages shall be as approved by the architect and custom messages shall be provided as directed.

W. Label locations of duct smoke detectors to indicate "Duct Smoke Detector Access".

X. Air Sampling Pipe and Sampling Point Network:

1. Where false ceilings are installed, the sampling pipe shall be installed above the ceiling, and Capillary Sampling Points shall be installed on the ceiling and connected by means of a capillary tube.

2. The minimum internal diameter of the Capillary tube shall be 3/8 in, the maximum length of the Capillary tube shall be 7ft unless the manufacturer in consultation with the engineer have specified otherwise.

3. The Capillary tube shall terminate at a Ceiling Sampling Point specifically designed and approved by the manufacturer. The performance characteristics of the Sampling Points shall be taken into account during the system design.

4. Air Sampling Pipe Network Calculations shall be provided by a sampling pipe aspiration modeling program such as ASPIRE2. Pipework calculations shall be supplied with the proposed pipe layout design to indicate the following performance criteria:

a. Transport Time

The manufacturers recommended transport time (time taken for the smoke to enter the pipe and reach the detector) for the least favorable sampling point is 60 seconds or less.
Local codes or end users standards may also apply. For example:
NFPA72 US : 120 Seconds

b. Balance %

The sample point balance for the pipe shall not be less than 70% as indicated by ASPIRE. That is, the volume of air drawn from the last sampling point shall not be less than 70% of the average volume of air through the other holes.

c. Share %

The sample hole share for the pipe shall not be less that 70% as indicated by ASPIRE. That is, the sum volume of air drawn through the sampling holes must always be greater than 70% of the total volume of air entering the pipe (i.e. the End Vent must not exceed 30% of the total flow).

d. Maximum number of sampling holes
(1) 100 per detector.
(2) 25 per pipe inlet.

3.03 WIRING OF COMBINATION FIRE/SMOKE AND SMOKE DAMPERS

A. The Division 23 mechanical contractor shall be responsible for all wiring of combination fire/smoke and smoke dampers, including all damper power as well as all damper control wiring.

B. Obtain sources of electrical power as directed on the electrical plans, in the electrical specifications, and herein. Provide such power wiring from the

source of power to the dampers and associated controls as required for a complete system installation.

C. Confer with the Division 23 temperature control contractor to ensure damper control sequences are in accordance with the sequences of operation outlined in Section 230923.

D. The Division 23 mechanical and temperature control contractors shall be responsible for ALL damper control – this includes life safety shut-down and control, smoke purge / exhaust sequence control, as well as standard operation for specified temperature control sequences.

E. Refer to Section 230923 for additional requirements.

3.04 FIELD QUALITY CONTROL

A. General Testing

1. Intelligent analog devices shall be tested for correct address and sensitivity using test equipment specifically designed for that purpose. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the system address, initials of the installing technician and date.

2. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.

a. A systematic record shall be maintained of readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates and witnesses.

b. The acceptance inspector shall be notified before the start of the required tests. Items found at variance with the drawings or this specification during testing or inspection by the acceptance inspector shall be corrected.

c. Test reports shall be delivered to the acceptance inspector as completed.

3. Test equipment, instruments, tools and labor required to conduct the system tests shall be made available by the contractor. The following equipment shall be a minimum for conducting the tests:

a. Ladders and scaffolds as required to access installed equipment.

b. Multi-meter for reading voltage (current and resistance).

c. Intelligent device programmer/tester (if required to set device addresses).

d. Laptop computer with programming software for any required program revisions.

d. Two way radios, flashlights, smoke generation devices and supplies.

e. A manufacturer recommended device for measuring air flow through air duct smoke detector sampling assemblies.

f. Decibel meter.

g. Spare printer paper.

h. Provide a testing kit for testing CO detectors in accordance with manufacturer's requirements.

4. In addition to the testing specified to be performed by the contractor, the installation shall be subject to test by the acceptance inspector.

5. System wiring: Fire alarm circuits shall be tested for continuity, grounds, and short circuits.

B. Air Sampling System Testing

1. Commissioning Tests

a. The contractor shall allow for the manufacturer's representative to attend commissioning of the entire installation in the presence of the owner and/or its representative.

b. All necessary instrumentation, equipment, materials and labor shall be provided by the Contractor.

c. The Contractor shall record all tests and system calibrations and a copy of these results shall be retained on site in the System Log Book.

2. System Checks

a. Visually check all pipes to ensure that all joints, fittings, bends, sampling points, etc., comply with the Specification.

b. Check the system to ensure the following features are operational and programmed in accordance with the specification.

- Alarm threshold levels (for both day and night settings),
- Pipes in use,
- Detector address,
- Display address,
- Clock and date,
- Time delays,
- Air flow fault thresholds,
- Display buttons operable (Mode, Silence, Reset, Isolate),
- Referencing
- Units set to U.S./S.I.,

c. Check to ensure that all ancillary warning devices operate as specified.

d. Check interconnection with Fire Alarm Control Panel to ensure correct operation.

3. Tests

a. Introduce Smoke into the Detector Assembly to provide a basic functional test.

b. Introduce smoke to the least favorable Sampling Point in each Sampling Pipe. Transport time is not to exceed the local codes (see 3.03).

c. If more than two bar graph divisions illuminate under normal conditions (no smoke test), review event log for two (2) weeks from date of commissioning and make appropriate adjustments to the alarm and delay thresholds.

d. Activate the appropriate Fire Alarm zones and advise all concerned that the system is fully operational. Fill out the log book and commissioning report accordingly.

C. Acceptance Testing

1. A written acceptance test procedure (ATP) for testing the fire alarm system components and installation will be prepared by the manufacturer in accordance with NFPA 72, and this specification. The contractor shall be responsible for the performance of the ATP,

demonstrating the function of the system and verifying the correct operation of system components, circuits, and programming.

2. The contractor shall prepare a program matrix referencing each alarm input to every output function affected as a result of an alarm condition on that input. In the case of outputs programmed using more complex logic functions involving "any", "or", "not", "count", "time", and "timer" statements; the complete output equation shall be referenced in the matrix.

3. A complete listing of device labels for alpha-numeric annunciator displays [and logging printers] shall be prepared by the contractor prior to the ATP.

4. The acceptance inspector shall use the system record drawings in combination with the documents specified under paragraph 3.01 during the testing procedure to verify operation as programmed. In conducting the ATP, the acceptance inspector shall request demonstration of any or input and output functions. The items tested shall include but not be limited to the following:

   a. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:

      (1) Open, shorted and grounded intelligent analog signaling circuit.
      (2) Open, shorted and grounded network signaling circuit.
      (3) Open and grounded conventional zone circuits.
      (4) Open and grounded signal and telephone circuits.
      (5) Intelligent device removal.
      (6) Primary power or battery disconnected.
      (7) Incorrect device at address.
      (8) Printer trouble, off line or out of paper.

   b. System evacuation alarm notification appliances shall be demonstrated as follows:

      (1) Alarm notification appliances actuate as programmed.
      (2) Audibility and visibility at required levels.

c. System indications shall be demonstrated as follows:

(1) Correct message display for each alarm input at the base building control panel and each remote alpha-numeric display [and each video display terminal].
(2) Correct annunciator light for each alarm input at each annunciator as shown on the drawings.
(3) Correct printer logging for system activity.

5. After the Contractor has completed his own acceptance test following the ATP procedure, and after the authorized fire alarm equipment representative has performed a 100% complete test of the system, an acceptance test of the fire alarm system will be conducted by the Contractor as directed by the Owner or his authorized representative.

6. In the event of system failure to perform as specified and programmed during the ATP procedure, at the discretion of the acceptance inspector, the test shall be terminated.

a. The contractor shall retest the system, correcting deficiencies and providing test documentation to the acceptance inspector.

b. The acceptance inspector may elect to require the complete ATP to be preformed again if, in his opinion, modifications to the system hardware or software warrant complete re-testing.

7. Before Final payment, the System Supplier shall turn over, to the owner, a disc copy and hard copy of the approved system custom program. Information shall be complete to allow for an alternate Factory Authorized Distributor to service, maintain, add, or delete devices as required.

3.05 SERVICES

A. The contractor shall warrant the entire system against mechanical and electrical defects for a period described in the contract general conditions. This period shall begin upon completed certification and test of the system or upon first beneficial use of the system, whichever is earlier.

B. The contractor or manufacturer shall offer for the owner’s consideration at the time of system submittal a priced inspection, maintenance, test and repair contract in full compliance with the requirements of NFPA 72.

1. The services offered under this contract shall be performed at no charge during the first year after system acceptance and the owner shall have the option of renewing for single or multiple years up to five years at the price quoted upon completion of the warranty period.

2. The contractor performing the contract services shall be qualified and listed to maintain ongoing certification of the completed system to the UL for specific installed system listing.

C. Furnish training as follows for a minimum of four employees of the system user:

1. Training in the receipt, handling and acknowledgement of alarms.

2. Training in the system operation including manual control of output functions from the system control panel.

3. Training in the testing of the system including logging of detector sensitivity, field test of devices and response to common troubles.

4. The total training requirement shall be a minimum of 24 hours or as required by the Owner, conducted on three successive days, but shall be sufficient to cover the items specified.

D. Prepare and start systems as directed by the Architect.

1. Include services of a certified technician to supervise adjustments and final connections, if required by the local authority having jurisdiction, to include: speaker tap setting, strobe intensity, detector sensitivity and door release adjustment.

3.06 WARRANTY

A. The contractor shall warrant the completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of one (1) year from the date of the completed and certified test or from the date of first beneficial use.

B. The equipment manufacturer shall make available to the owner a maintenance contract proposal to provide a minimum of two (2) inspections and tests per year in compliance with NFPA-72 guidelines.

END OF SECTION 28 31 00

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing site utilities.
7. Temporary erosion- and sedimentation-control measures.

1.2 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

E. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.

5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Architect.

3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.

1. Arrange with utility companies to shut off indicated utilities.

B. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Removal of underground utilities is included in earthwork sections and with applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security and utilities sections.

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
2. Use only hand methods for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of 6 inches (150 mm) in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for concrete slabs-on-grade.
4. Subbase course for concrete walks pavements.
5. Subbase course and base course for asphalt paving.
6. Excavating and backfilling for utility trenches.
7. Contractor is also to reference a copy of the geotechnical engineer's soils report for the project in conjunction with these specification sections.

1.2 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 QUALITY ASSURANCE

A. Pre-excavation Conference: Conduct conference at Project site.

1.4 PROJECT CONDITIONS

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth moving operations.

B. Do not commence earth moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487 and Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

1. Liquid Limit: 40.
2. Plasticity Index: 10.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 and Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

H. Drainage Course: Narrowly graded mixture of [washed]crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.

2.2 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored to comply with local practice or requirements of authorities having jurisdiction.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.5 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches (300 mm) each side of pipe or conduit or As indicated.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material, 4 inches (100 mm) deeper elsewhere, to allow for bedding course.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.6 SUBGRADE INSPECTION

A. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired dump truck to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in "Cast-in-Place Concrete"

D. Trenches under Roadways: Provide 4-inch- (100-mm-) thick, concrete-base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway subbase course. Concrete is specified in "Cast-in-Place Concrete"

E. Place and compact initial backfill of subbase material , free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Place and compact final backfill of satisfactory soil to final subgrade elevation.

G. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.10 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

3.11 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 12 inches (304 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 100 percent.
2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 95 percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.13 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch (25 mm).
2. Walks: Plus or minus 1/2 inch (13 mm).
3. Pavements: Plus or minus 1/2 inch (13 mm).

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

3.14 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:

1. Shape subbase course and base course to required crown elevations and cross-slope grades.
2. Place subbase course and base course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.

3. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.15 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.16 FIELD QUALITY CONTROL

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

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 312319 - DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes construction dewatering.

1.2 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.3 FIELD CONDITIONS

A. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide temporary grading to facilitate dewatering and control of surface water.

B. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 015000 "Temporary Facilities and Controls," and Section 311000 "Site Clearing," during dewatering operations.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
3. Maintain piezometric water level a minimum of 24 inches (600 mm) below bottom of excavation.

C. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

END OF SECTION 312319

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil treatment with termiticide.
2. Bait-station system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include the EPA-Registered Label for termiticide products.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Soil Treatment Application Report: Include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

C. Bait-Station System Application Report: Include the following:

1. Location of areas and sites conducive to termite feeding and activity.
2. Plan drawing showing number and locations of bait stations.
3. Dated report for each monitoring and inspection occurrence indicating level of termite activity, procedure, and treatment applied before time of Substantial Completion.
4. Termiticide brand name and manufacturer.
5. Quantities of termiticide and nontoxic termite bait used.
6. Schedule of inspections for one year from date of Substantial Completion.

D. Warranties: Sample of special warranties.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project

is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

B. Regulatory Requirements: Formulate and apply termiticides and termiticide devices according to the EPA-Registered Label.

C. Pre-installation Conference: Conduct conference at Project site.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.

B. Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

C. Install bait-station system during construction to determine areas of termite activity and after construction, including landscaping, is completed.

1.6 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: Five years from date of Substantial Completion.

1.7 MAINTENANCE SERVICE

A. Continuing Service: Beginning at Substantial Completion, provide 12 months' continuing service including monitoring, inspection, and re-treatment for occurrences of termite activity. Provide a standard continuing service agreement. State services, obligations, conditions, terms for agreement period, and terms for future renewal options.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

A. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. BASF Corporation, Agricultural Products; Termidor.
    b. Bayer Environmental Science; Premise 75.
    c. FMC Corporation, Agricultural Products Group; Dragnet FT, Talstar, Prevail.
    d. Syngenta; Demon TC, Prelude, Probuild TC.

2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

2.2 BAIT-STATION SYSTEM

A. Provide bait stations based on the dimensions of building perimeter indicated on Drawings, according to manufacturer's EPA-Registered Label for product, manufacturer's written instructions, and the following:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. BASF Corporation, Agricultural Products; Subterfuge.
    b. Dow AgroSciences LLC; Sentricon System.
    c. Ensystex, Inc.; Exterra System.
    d. FMC Corporation, Agricultural Products Group; First Line.
    e. Whitmire Micro-Gen Research Laboratories, Inc.; Advance TBS.

2. No fewer than one bait station per 8 linear feet (2.4 linear meters).
3. No fewer than one cluster of bait stations per 20 linear feet (6.1 linear meters), consisting of no fewer than three bait stations per cluster.

PART 3 - EXECUTION

3.1 APPLICATION, GENERAL

A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.

3.2 APPLYING SOIL TREATMENT

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.

B. Proceed with application only after unsatisfactory conditions have been corrected.

C. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be

treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.

1. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

D. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.

1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
2. Foundations: Adjacent soil, including soil along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
3. Crawlspaces: Soil under and adjacent to foundations as previously indicated. Treat adjacent areas including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
4. Masonry: Treat voids.
5. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.

E. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.

F. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

G. Post warning signs in areas of application.

H. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.3 INSTALLING BAIT-STATION SYSTEM

A. Place bait stations according to the EPA-Registered Label for the product and manufacturer's written instructions, in the following areas that are conducive to termite feeding and activity:

1. Conducive sites and locations indicated on Drawings.
2. In and around infested trees and stumps.
3. In mulch beds.
4. Where wood directly contacts soil.
5. Areas of high soil moisture.

6. Near irrigation sprinkler heads.
7. Each area where roof drainage system, including downspouts and scuppers, drains to soil.
8. Along driplines of roof overhangs without gutters.
9. Where condensate lines from mechanical equipment drip or drain to soil.
10. At plumbing penetrations through ground-supported slabs.
11. Other sites and locations as determined by licensed Installer.

B. Inspect and service bait stations from time of their application until Substantial Completion unless extended by continuing service agreement, according to the EPA-Registered Label for product and manufacturer's written instructions for termite management system and bait products.

1. Service Frequency: Inspect bait stations not less than once every three month(s).

END OF SECTION 313116

SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes temporary excavation support and protection systems.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 INFORMATIONAL SUBMITTALS

A. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

B. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.4 FIELD CONDITIONS

A. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide, design, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.

PART 3 - EXECUTION

3.1 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.2 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches (1500 mm). Accurately align exposed faces of sheet piling to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.3 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.4 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.

3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

3.6 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlying construction and abandon remainder.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION 315000

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.

B. Related Requirements:

1. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
2. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **Project site**.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each paving material. **Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.**

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: **A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located**.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the 2006 Specifications Book of North Carolina **DOT**> for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

B. Fine Aggregate: **ASTM D 1073 or AASHTO M 29**, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

C. Mineral Filler: **ASTM D 242/D 242M or AASHTO M 17**, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320, **PG 70-22**.

B. Tack Coat: **ASTM D 977 or AASHTO M 140** emulsified asphalt, or **ASTM D 2397 or AASHTO M 208** cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires, asphalt shingles, or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

2.4 MIXES

A. Recycled Content of Hot-Mix Asphalt: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **10** percent or more than **15** percent by weight.

1. Surface Course Limit: Recycled content no more than **10** percent by weight.

B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes **approved by authorities having jurisdiction.**

PART 3 - EXECUTION

3.1 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth of **1-1/2 inches (38 mm)**.
2. Patch surface depressions deeper than 1 inch (25 mm) after milling, before wearing course is laid.

3.2 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Spread mix at a minimum temperature of 250 deg F (121 deg C).
2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/4 inch (6 mm), no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Base Course: **1/4 inch (6 mm)**.
2. Surface Course: **1/8 inch (3 mm)**.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

3.8 FIELD QUALITY CONTROL

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

B. Replace and compact hot-mix asphalt where core tests were taken.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.9 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Driveways.
2. Roadways.
3. Parking lots per Landscape Designer construction documents.
4. Curbs and gutters per Landscape Designer construction documents.
5. Walks per Landscape Designer construction documents.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Samples: For each exposed product and for each color and texture specified.

D. Other Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.3 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

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

C. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.

D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

E. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.

F. Deformed-Steel Wire: ASTM A 496/A 496M.

G. Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars; zinc coated (galvanized) after fabrication according to ASTM A 767/A 767M, Class I coating. Cut bars true to length with ends square and free of burrs.

H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.2 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150, gray portland cement Type I, Supplement with the following:

a. Fly Ash: ASTM C 618, Class C or Class F.
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

2. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag cement.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, uniformly graded. Provide aggregates from a single source.

C. Water: Potable and complying with ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

F. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Color: As selected by Architect from manufacturer's full range.

2.3 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

2.4 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 3, 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. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

2.5 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

2.6 PAVEMENT MARKINGS

A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than [three] [45] minutes.

1. Color: White or Yellow As indicated.

B. Pavement-Marking Paint: MPI #97 Latex Traffic Marking Paint.

1. Color: White or Yellow As indicated.

2.7 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete.

1. Color: Gray.
2. Dowels: Galvanized steel, 3/4 inch (19 mm) in diameter, 10-inch (254-mm) minimum length.
3. Adhesive: As recommended by wheel stop manufacturer for application to concrete pavement.

2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), with the following properties:

1. Compressive Strength (28 Days): 4500 psi (31 MPa), 4000 psi (27.6 MPa), 3500 psi (24.1 MPa), 3000 psi (20.7 MPa) as indicated.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
4. Air Content: 5-1/2 percent plus or minus 1.5 percent.

B. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

C. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).

D. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M. Furnish batch certificates for each batch discharged and used in the Work.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

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

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

D. 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, or to match jointing of existing adjacent concrete paving:

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, placing, and consolidating concrete.

C. 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.

D. Screed paving surface with a straightedge and strike off.

E. 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.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface according to manufacturer's written instructions.

1. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
2. After curing, lightly work surface with a steel wire brush or abrasive stone and water to expose nonslip aggregate.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these.

3.8 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Joint Spacing: 3 inches (75 mm).
5. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
6. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.9 PAVEMENT MARKING

A. Allow concrete paving to cure for a minimum of 28 days and be dry before starting pavement marking.

B. Sweep and clean surface to eliminate loose material and dust.

C. Apply paint with mechanical equipment to produce markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).

3.10 WHEEL STOPS

A. Install wheel stops in bed of adhesive applied as recommended by manufacturer.

B. Securely attach wheel stops to paving with not less than two steel dowels located at one-quarter to one-third points. Install dowels in drilled holes in the paving and bond dowels to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 32 13 16
DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

1. Section includes colored concrete paving.
2. Plain concrete pedestrian pavement.

B. Related Sections:

1. Division 03 Section "Cast-in-Place Concrete" for general building applications of concrete.
2. Division 03 Section "Architectural Concrete" for general building applications of specially finished formed concrete.
3. Division 32 Section "Concrete Paving" for cast-in-place concrete paving with other finishes, curbs and gutters, stamped detectable warnings, pavement markings, and wheel stops.
4. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within decorative concrete paving and in joints between decorative concrete paving and asphalt paving or adjacent construction.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

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

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color, pattern, or texture selection.

C. Samples for Verification: For each type of exposed color, pattern, or texture indicated.

D. Other Action Submittals:

1. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer .

B. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Admixtures.
3. Curing compounds.
4. Joint fillers.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.

B. Source Limitations: Obtain decorative concrete paving products and each type or class of cementitious material of the same brand from same manufacturer's plant, and obtain each aggregate from single source.

C. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

D. ACI Publications: Comply with ACI 301 unless otherwise indicated.

E. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; surface color, pattern, and texture; curing; and standard of workmanship.
2. Build mockups of decorative concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 60 inches by 60 inches.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

F. Preinstallation Conference: Conduct conference at Project site .

1. Review methods and procedures related to decorative concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and decorative concrete paving construction practices.
c. Decorative concrete finishes.

2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete manufacturer.
d. Decorative concrete paving Installer.
e. Manufacturer's representative of decorative concrete paving system.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves of a radius of 100 feet or less. Do not use notched and bent forms.

B. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.

C. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150, gray portland cement Type I/II . Supplement with the following:

a. Fly Ash: ASTM C 618, Class C or F.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S , uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Aggregate Size: 1 inch nominal.

2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: Potable and complying with ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not 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.

F. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis. Color to be selected by Architect from manufacturer’s full range, meluding carbon black.

2.3 CURING AND SEALING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

B. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type I, Class B, manufactured for colored concrete.

1. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

2.4 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

2.5 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 , for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 3000 psi.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 5 inches, plus or minus 1 inch.

C. 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-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture in concrete as required for placement and workability.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.

G. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.6 CONCRETE MIXING

A. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete batches larger than 1 cu. yd. , increase mixing time by 15 seconds for each additional 1 cu. yd. .
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Division 31 Section "Earth Moving."

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

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
1. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
2. Dowelled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent decorative concrete paving:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

a. Tolerance: Ensure that sawed joints are within 3 inches in both directions from center of dowels.

3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installationand items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surfacebefore placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assembliesor side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

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 design mixtures.

K. 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 in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

3.7 INTEGRALLY COLORED CONCRETE FINISH

A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
   1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Compound: Apply curing compound immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after application. Maintain continuity of coating, and repair damage during curing period.

   1. Cure integrally colored concrete with a pigmented curing compound.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

   1. Elevation: 3/4 inch .
   2. Thickness: Plus 3/8 inch , minus 1/4 inch .
   3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 1/2 inch .
   4. Lateral Alignment and Spacing of Dowels: 1 inch .
   5. Vertical Alignment of Dowels: 1/4 inch .
   6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
   7. Joint Spacing: 3 inches .
   8. Contraction Joint Depth: Plus 1/4 inch , no minus.
   9. Joint Width: Plus 1/8 inch , no minus.

3.10 FIELD QUALITY CONTROL

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

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

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 mixture. 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 mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi .

D. 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.

E. 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.

F. 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.

G. Decorative concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.11 REPAIRS AND PROTECTION

A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.12 DECORATIVE CONCRETE PAVING SCHEDULE

A. Patterned Decorative Concrete Paving :

1. Locations: Install at locations indicated.
2. Coloring Method: Integrally colored .

a. Color: As selected by Architect from manufacturer's full range .

END OF SECTION 321316

SECTION 321373

CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.

B. Related Sections:

1. Division 07 Section "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.
2. Division 32 Section "Asphalt Paving" for constructing joints between concrete and asphalt pavement.
3. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.3 PRECONSTRUCTION TESTING

A. 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 ASTM C 1087 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 no fewer than four 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, not older than 24 months, of sealant products for compatibility with and adhesion to joint substrates and other materials matching those submitted.

1.4 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants 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.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer .

B. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.

1.7 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 joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

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: Dark grey.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant for Concrete: ASTM D 5893, Type NS.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Crafco Inc., an ERGON company; RoadSaver Silicone.
b. Dow Corning Corporation; 888.
c. Pecora Corporation; 301 NS.

2.3 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant for Concrete: ASTM D 3406.

B. Hot-Applied, Single-Component Joint Sealant for Concrete and Asphalt: ASTM D 6690, Types I, II, and III.

2.4 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; 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- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.5 NEOPRENE JOINT SEALANTS

A. Closed cell, black neoprene material with adhesive backing.

PART 3 - EXECUTION

3.1 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.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

3.3 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. Joint-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 joint-sealant backings of kind indicated to support joint 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 joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place joint sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses in 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 Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements 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 joint sealant from surfaces adjacent to joints.
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.

3.4 CLEANING

A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 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 in repaired areas are indistinguishable from the original work.

END OF SECTION 32 13 73

SECTION 321713 - PARKING BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wheel stops.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 PARKING BUMPERS

A. Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete, 4000-psi (27.6-MPa) minimum compressive strength, 4-1/2 inches (115 mm high by 9 inches (225 mm) wide by 72 inches (1800 mm) long . Provide chamfered corners, transverse drainage slots on underside, and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

1. Mounting Hardware: Galvanized-steel spike or dowel, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length .

B. Resilient Wheel Stops: Solid, integrally colored, 96 percent postconsumer or commingled postconsumer and preconsumer recycled rubber or plastic; UV stabilized; 4 inches (100 mm) high by 6 inches (150 mm) wide by 72 inches (1800 mm) long . Provide chamfered corners and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Checkers Industrial Safety Products, Inc.

b. GNR Technologies.
c. Plastic Safety Systems, Inc.
d. Scientific Developments, Inc.
e. Technoflex.
f. Traffic Logix.

3. Color: Gray or Green.
4. Embedded Markings: Molded-in, white or yellow reflective markings, permanently inset in exposed surface.
5. Mounting Hardware: Galvanized-steel spike or dowel, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length.
6. Adhesive: As recommended by wheel-stop manufacturer for adhesion to pavement.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install wheel stops according to manufacturer's written instructions unless otherwise indicated.

B. Install wheel stops in bed of adhesive before anchoring.

C. Securely anchor wheel stops to pavement with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer.

END OF SECTION 321713

SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For interior, field-applied, pavement-marking paints, documentation including printed statement of VOC content.

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Aexcel Inc.
2. Benjamin Moore & Co.
3. Color Wheel Paints & Coatings.
4. Columbia Paint & Coatings.
5. Conco Paints.
6. Coronado Paint; Division of INSL-X Products Corporation.
7. Diamond Vogel Paints.
8. Dunn-Edwards Corporation.
9. Ennis Traffic Safety Solutions, Inc.
10. Frazee Paint.
11. General Paint.
12. Kwal Paint.

13. M.A.B. Paints.
14. McCormick Paints.
15. Miller Paint.
16. Parker Paint Mfg. Co. Inc.
17. PPG Industries.
18. Pratt & Lambert.
19. Rodda Paint Co.
20. Rohm and Haas Company; a subsidiary of The Dow Chemical Company.
21. Scott Paint Company.
22. Sherwin-Williams Company (The).

2.2 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint: MPI #32, alkyd traffic-marking paint.

1. Color: As indicated.

B. Pavement-Marking Paint: MPI #97, latex traffic-marking paint.

1. Color: As indicated.

C. Glass Beads: AASHTO M 247, Type 1 made of 100 percent recycled glass.

D. VOC Content: Pavement markings used on building interior shall have a VOC content of 150 g/L or less.

PART 3 - EXECUTION

3.1 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).

1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils. Apply paint so that it cannot run beneath the stencil.
2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal. (0.72 kg/L).

END OF SECTION 321723

SECTION 32 31 19 - DECORATIVE METAL FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Decorative aluminum fences.
   2. Swing gates.

B. Related Requirements:

   1. Section 033000 "Cast-in-Place Concrete" for post concrete fill.
   2. Section 281300 "Access Control" for access control devices installed at gates and provided as part of a security system.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

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

C. Samples: For each fence material and for each color specified.

   1. Provide samples 12 inches in length for linear materials.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Test Reports: For decorative metallic-coated-steel tubular picket fences, including finish, indicating compliance with referenced standard.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For gate operators to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.

1. Include 10-foot length of fence complying with requirements.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE ALUMINUM FENCES

A. Decorative Aluminum Fences: Fences made from aluminum extrusions.

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

a. Alumi-Guard, Inc
b. Ameristar Fence Products
c. Carfaro, Inc
d. Ideal Aluminum Products
e. Jerith Manufacturing Company, Inc
f. Master Halco

B. Posts: see Plans for post dimensions.

C. Post Caps: Aluminum castings.

D. Rails: Square tubes.

1. Size: See Plans.
2. Metal and Thickness: 0.079-inch nominal-thickness, metallic-coated steel sheet or 0.075-inch nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.

E. Pickets: Square tubes.

F. Fasteners: Manufacturer's standard concealed fastening system.

G. Fasteners: Manufacturer's standard tamperproof, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers.

H. Fabrication: Assemble fences into sections by welding pickets to rails.

1. Fabricate sections with clips welded to rails for field fastening to posts.
2. Drill clips for fasteners before finishing.

I. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.

J. Finish: Baked enamel or powder coating.

2.3 SWING GATES

A. Gate Configuration: Double leaf As indicated.

B. Gate Frame Height: 72 inches.

C. Gate Opening Width: As indicated.

D. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes as shown with 0.140-inch wall thickness.

E. Frame Corner Construction: Welded.

F. Additional Rails: Provide as indicated, complying with requirements for fence rails.

G. Infill: Comply with requirements for adjacent fence.

H. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.

I. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet wide. Provide center gate stops and cane bolts for pairs of gates.

J. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.

1. Function: 39 - Full surface, triple weight, antifriction bearing.
2. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.

K. Mortise Locks: BHMA A156.13, Grade 1, suitable for exterior use.

1. Function: F17 - Deadlock.
2. Material: Brass or bronze.
3. Levers: Cast, forged, or extruded brass or bronze.

4. Mounting Box: Configuration necessary to enclose locks. Fabricate from 1/8-inch-thick aluminum plate.

L. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push pad actuating bar, suitable for exterior use.

1. Function: Exit only, no trim or blank escutcheon. Entrance by trim when latch bolt is released by key or set in a retracted position by key. Entrance by lever. Key locks or unlocks lever. Entrance by lever only when released by key. Key removable only when locked.
2. Mounting Channel: Bent-plate channel formed from 1/8-inch- thick, steel plate. Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending 1/8 inch beyond push pad surface.

M. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from 3/4-inch- diameter, round steel bars, hot-dip galvanized after fabrication. Finish to match gates. Provide galvanized-steel pipe strikes to receive cane bolts in both open and closed positions.

N. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.

O. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.

P. Aluminum Finish: Baked enamel or powder coating.

Q. Color: Black.

2.4 ALUMINUM

A. Aluminum, General: Provide alloys and tempers with not less than the strength and durability properties of alloy and temper designated in paragraphs below for each aluminum form required.

B. Extrusions: ASTM B 221 , Alloy 6063-T5.

C. Tubing: ASTM B 429/B 429M, Alloy 6063-T6.

D. Plate and Sheet: ASTM B 209 , Alloy 6061-T6.

E. Die and Hand Forgings: ASTM B 247 , Alloy 6061-T6.

F. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.5 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

1. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for strength and compatibility in fabricated items.

B. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi , 3-inch slump, and 1-inch maximum aggregate size.

C. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M and specifically recommended by manufacturer for exterior applications.

2.6 GROUNDING MATERIALS

A. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Aluminum.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1 inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Grounding Connectors and Grounding Rods: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic-welded type.
2. Grounding Rods: Copper-clad steel.

a. Size: 5/8 by 96 inches .

2.7 ALUMINUM FINISHES

A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 2 mils . Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: Black, Satin finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.

B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 DECORATIVE FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening rails and infill panels to posts.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches plus 3 inches for each foot or fraction of a foot that fence height exceeds 4 feet .

D. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

    a. Exposed Concrete: Extend 2 inches above grade. Finish and slope top surface to drain water away from post.
    b. Concealed Concrete: Top 3 inches below grade as indicated on Drawings to allow covering with surface material. Slope top surface of concrete to drain water away from post.

3. Posts Set in Concrete: Extend post to within 6 inches of specified excavation depth, but not closer than 3 inches to bottom of concrete.
4. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least 3/4 inch larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.

    a. Extend posts at least 5 inches into sleeve.
    b. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.

5. Posts Set into Voids in Concrete: Form or core drill holes not less than 3/4 inch larger than outside diagonal dimension of post.

    a. Extend posts at least 5 inches into concrete.
    b. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout

manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.

6. Mechanically Driven Posts: Drive into soil to depth of 30 inches. Protect post top to prevent distortion.
7. Space posts uniformly at 8 feet o.c.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.5 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet Insert a lesser distance if grounding resistance is high except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

a. Gates and Other Fence Openings: Ground fence on each side of opening.

1) Bond metal gates to gate posts.
2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

F. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.

3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.6 FIELD QUALITY CONTROL

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

1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
3. Report: Prepare test reports of grounding resistance at each test location certified by a testing agency. Include observations of weather and other phenomena that may affect test results.

3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Automatic Gate Operators: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, and limit switches.

1. Hydraulic Operators: Purge operating system, adjust pressure and fluid levels, and check for leaks.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Train Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 323119

SECTION 32 84 00 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1. 012100 – Allowances
2. 22113 – Facility Water Distribution Piping

1.2 SUMMARY

A. The Drawings and Specifications herein apply to the Point of Connection and downs stream.

B. Section Includes:

1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

1.3 DEFINITIONS

A. Irrigation Supply: Upstream of the Point of Connection, the irrigation supply includes the back flow preventer, the meter, feeds and taps.

B. Point of Connection: Defined as the below ground discharge from the backflow preventer.

C. Irrigation System: Defined as components of the system that are located immediately down stream of the point of connection. See Engineering drawings and specifications for upstream portions of the system

D. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

E. System Main Feed – The piping and fittings required to move water from the Point of Connection to 5' beyond the Main Isolation Valve

F. Main Isolation Valve – A master valve capable of shutting off the entire system before the system main splits - as located on the plan.

G. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 PERFORMANCE REQUIREMENTS

A. This Section describes work down stream of the Irrigation Supply (backflow device). See Division 22 Section "Facility Water Distribution Piping" for taps, meter, and backflow device.
   1. Follow NC General Statute 143-355.4 for separate meters and taps for irrigation systems.

B. The design must meet the following design guidelines:
   1. Requirements supplied by local municipalities;
   2. Requirement provided by the US Marine Corps.

C. Pressure – The Contractor is responsible for delivering a system capable of delivering working pressures to the equipment that are according to the manufacturer's recommendations.
   1. The Contractor shall provide an Allowance (see 012100 – Allowances) to install an irrigation pressure booster pump to provide working pressures needed for efficient operation within the manufacturer's guidelines.
   2.

D. Irrigation zone control shall be automatic operation with controller and automatic control valves.

E. High rate delivery systems such as flood bubblers are not allowed.

F. Provide only high efficiency equipment capable of providing water accurately and efficiently. The system shall use drip irrigation for plants and spray for turf.

G. Provide an irrigation system that completely separates lawn irrigation from shrub irrigation. Maintain 100 percent head to head irrigation coverage of areas indicated.

H. No main piping or control wiring shall be located outside property lines or within road right of ways. Other system components may be allowed by the local municipality.

I. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and lights.

J. No valves, fittings, or joints are to be placed under paved surfaces, curbs or sidewalks. Where possible, crossing shall be uninterrupted stretches of pipe within sleeves sized according to the drawings.

K. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation System Feed: 400 psig.
2. Irrigation Main Piping and Circuit Piping: 200 psig .

L. The following are soil conditions found at the site:

a. Structure: The soil structure of the site is compacted due to working and construction activity. This compaction will reduce standard infiltration rates.
b. Infiltration Rate:

1) Sandy loam: .5-.8 in/hr.
2) Clay loam: .4--.5 in/hr
3) Clay: .2-.3 in/hr.

M. Drip Emitters Per Plant – use the following guide to set the number of emitters per plant, based upon a 2 hour watering window [WW] and delivering matched water delivery per zone.

TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS

Type of plant	Plant Size at installation	Gal. Per week [X]	Gal/ WW	Minimum # emitters per plant	# emitters per plant at .5 gph	# emitters per plant at 1.0 gph	# emitters per plant at 1.5 gph	# emitters per plant at 2.0 gph	# emitters per plant at 3.0 gph
Tree	5-7” caliper tree	100	7.1	6	14	7	5	4	2
	2.5” to 4” caliper	60	4.3	4	9	4	3	2	1
Shrub	8-10’ BB shrub	40	2.9	4	6	3	2	1	1
	5-7’ BB shrub	20	1.4	3	3	1	1	1	N/A
	3-6’ container shrub	10	0.7	2	2	2	N/A	N/A	N/A
	8” – 30” shrub or groundcover	7	0.5	1	1	1	N/A	N/A	N/A
Grasses and Perenni-als	Quart size plant	5	0.4	1	1	N/A	N/A	N/A	N/A
Plugs	4” pot and less	3		Grid of drip. See below					

- Minimum emitters per plant equals what is required to fully wet the root ball perimeter, not just one side
- Emitters should be placed 4-6" inside the root ball
- N/A – less than one emitter which is not possible
- Grid of drip should be the same rate as the plant spacing
- The Contractor shall use this table as a guide. Provide refinement of the system for different plant types and soil conditions.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Equipment Numbering System

C. Use a coordinated numbering system for shop drawings, as-builts and field labeling as follows:
1. Turf Valves – Use 1-50
2. Drip Valves – Use 51-99
3. Valves, Pressure Regulators & Other Equipment - Use 100 and above

D. Delegated-Design Submittal [Shop Drawings]: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional designer responsible for their preparation. Submittal should include irrigation systems, drawn to scale in a CAD software (contact the Landscape Architect for CAD backgrounds), showing the following:

1. Main piping
2. Circuit piping
3. Stream and spray rotors – with graphic radius indicated
4. Automatic control valves
5. Point of Connection location
6. Time clock and rain sensor location
7. Blow-off valves, isolation valves, quick coupler connections,
8. Numbered valves with GPM calculated for each
9. Coordination with site elements and utilities.
10. Required Pressure at Point of Connection – The irrigation designer shall state the pressure required of irrigation system in PSI.
11. System Pressure Loss – The designer shall state the calculated pressure loss from the Point of Connection to the furthest automated valve in PSI on the drawing.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. System Manual: A hard cover, 3 ring bound, exterior project titled, with table of contents for sprinklers, controllers, pumps, quick couplers, rain sensors, and automatic control valves to include the following:
   1. Product cut sheets designating exact model number(s)
   2. Written schedule of operation including a winterization date, start up date, and controller timing schedule suggestions for spring, summer, and fall.
   3. Operation and Maintenance information of the provided equipment including a schedule of routine maintenance for cleaning and adjusting equipment.
   4. Reduced as-built plans bound with in the manual or in plastic sleeves.

B. Prepare an as-built CAD drawing of the installed system. The drawings shall be legible with no overlapping or hidden graphics. Provide enlargements of crowded or obscured areas. Take field measurements and indicate on the drawings the dimensions of key elements from known site points such as the buildings and roadways to showing installed conditions of the following equipment:

   1. Heads
   2. Main lines and lateral lines
   3. Automatic valves, manual valves, blow-offs and quick couplers
   4. Tap, meter, backflow, time clock and rain sensor
   5. Circuit and sensor wires
   6. Valve numbers corresponding to the time clock labeling, zone designation, and GPM for each zone.

1.8 MATERIALS MAINTENANCE SUBMITTALS [ATTIC STOCK]

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

   1. Stream Rotors: Equal to 5% percent of amount installed for each type and size indicated, but no fewer than 5 units with filters and a selection of matching nozzles.
   2. Spray Sprinklers: Equal to 5% percent of amount installed for each type and size indicated, but no fewer than 5 units with filters and a selection of nozzles.
   3. Drip-Tube System Tubing: Equal to 2% percent of total length installed for each type and size indicated, but not less than 100 feet.
   4. Drip emitters – provide 10 of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers that include a [certified irrigation designer qualified by The Irrigation Association] [Professional Class member of the American Society of Irrigation Consultants] [Professional Technical Class member of the American Society of Irrigation Consultants] <Insert qualifications>.

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

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.11 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Architect and Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Owner's written permission.
3. Do not proceed with irrigation work until rough grade approval is given by the Landscape Architect.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes. Supply components having pressure rating equal to or greater than system operating pressure.

B. Underground irrigation System Main Feed shall be the following:
1. Schedule 80, PVC socket fittings; and solvent-cemented joints.

C. Underground irrigation Main Piping shall be the following:
1. SDR 200, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

D. Circuit piping shall be the following:
1. SDR 200, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

E. Risers to Aboveground drip lines: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

2.2 PIPING JOINING MATERIALS

A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656. Use a color tinted material.

2.3 MANUAL VALVES

A. Plastic Ball Valves:

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

a. American Valve, Inc.
b. Asahi/America, Inc.
c. Colonial Engineering, Inc.
d. Fischer, George Inc.
e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
f. IPEX Inc.
g. Jomar International, LTD.
h. KBI (King Bros. Industries).
i. Legend Valve.
j. NIBCO INC.
k. Sloane, George Fischer, Inc.
l. Spears Manufacturing Company.
m. Thermoplastic Valves Inc.
n. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-122.
b. Pressure Rating: 200 psig .
c. Body Material: PVC.
d. Type: Union.
e. End Connections: Socket or threaded.
f. Port: Full.

2.4 PRESSURE-REDUCING VALVES

A. Water Pressure Regulators:

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

a. Cash Acme; a division of The Reliance Worldwide Corporation.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Honeywell International Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

a. Standard: ASSE 1003.
b. Body Material: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved.

c. Pressure Rating: Initial pressure of 150 psig .
d. End Connections: Threaded for NPS 2 and smaller.

2.5 AUTOMATIC CONTROL VALVES

A. High Flow Plastic, automatic Control Valves for lawn sprinklers:

1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid. For flow ranges from 5 to 100 gpm.

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

a. Buckner; a division of Storm Manufacturing Group Inc.
b. Ceres Products Company.
c. Champion Irrigation Products.
d. Dig Corporation.
e. Greenlawn Sprinkler Company.
f. Hit Products Corporation.
g. Hunter Industries Incorporated.
h. Irritrol Systems.
i. Nelson, L. R. Corporation.
j. Netafim USA.
k. Olson Irrigation Systems.
l. Orbit Irrigation Products, Inc.
m. Rain Bird Corporation.
n. Superior Controls Co., Inc.
o. Toro Company (The); Irrigation Division.
p. Weathermatic.

B. Low Flow Drip Control Valves :

1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid. For flow ranges below 5 gpm.

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

a. Buckner; a division of Storm Manufacturing Group Inc.
b. Ceres Products Company.
c. Champion Irrigation Products.
d. Dig Corporation.
e. Greenlawn Sprinkler Company.
f. Hit Products Corporation.
g. Hunter Industries Incorporated.
h. Irritrol Systems.

i. Nelson, L. R. Corporation.
j. Netafim USA.
k. Olson Irrigation Systems.
l. Orbit Irrigation Products, Inc.
m. Rain Bird Corporation.
n. Superior Controls Co., Inc.
o. Toro Company (The); Irrigation Division.
p. Weathermatic.

2.6 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig .

2.7 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings:

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

a. Cascade Waterworks Manufacturing.
b. Dresser, Inc.; DMD Division.
c. Ford Meter Box Company, Inc. (The).
d. JCM Industries.
e. Smith-Blair, Inc; a Sensus company.
f. Viking Johnson.

2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Metal to Plastic Transition Fittings at Point of Connection:

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

a. Harvel Plastics, Inc.
b. Spears Manufacturing Company.

2. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket or threaded end.

2.8 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.

B. Pressure Gages: ASME B40.1. Include 4-1/2-inch- diameter dial, dial range of two times system operating pressure, and bottom outlet.

C. Detectable Warning Tape: Provide detectable warning tape with “IRRIGATION LINE” clearly marked and a unique color.

2.9 QUICK COUPLERS

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

1. Hunter Industries Incorporated.
2. Nelson, L. R. Corporation.
3. Rain Bird Corporation.
4. Toro Company (The); Irrigation Division.
5. Weathermatic.

B. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap;

C. Key – Provide factory-fabricated brass one piece swiveling connector with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet. Provide one key per installed quick coupler with a minimum number of two.

2.10 RAIN SENSOR

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

1. Hunter Industries Incorporated.
2. Nelson, L. R. Corporation.
3. Rain Bird Corporation.
4. Toro Company (The); Irrigation Division.
5. Weathermatic.

B. Description: UL listed, UV stabilized plastic housing rain sensor with the following properties:
1. Hardwire installation
2. 2-5 minute time duration to system shut down

3. Time to reset should be less than 4 hours
4. Operating temperature range 32 – 130 degrees
5. 24 volt, 3amp
6. Matched to controller station
7. Selectable rain shut off indexes at 1/8", ¼", ½". ¾" of rainfall

2.11 DRIP IRRIGATION SPECIALTIES

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

1. Agrifim.
2. Aquarius Brands, Inc.
3. Buckner; a division of Storm Manufacturing Group Inc.
4. Dig Corporation.
5. Geoflow, Inc.
6. Hendrickson Bros.
7. Hit Products Corporation.
8. Irritrol Systems.
9. Maxijet, Inc.
10. NDS/Raindrip.
11. Netafim USA.
12. Olson Irrigation Systems.
13. Orbit Irrigation Products, Inc.
14. Rain Bird Corporation.
15. Roberts Irrigation Products, Inc.
16. Salco Products.
17. Toro Company (The); Irrigation Division.

B. In-line [inside pipe] Emitter Systems:

1. Tubing: PE or PVC; 1/2-inch minimum ID, UV resistant.
2. Emitter: In-pipe device .

    a. Body Material: UV Resistant PE or Vinyl
    b. Design Flow: .5 to 1.0 gph.
    c. Spacings 12" to 18" oc..
    d. Pressure compensating from 15-50 psi
    e. Minimum operation pressure if 15 psi
    f. Minimum filtration 120 mesh
    g. Self flushing design
    h. Includes an internal low pressure 2 psi check valve
    i. Includes a non chemical physical or copper root barrier

C. On-line [on pipe] Emitter Systems:

1. Tubing: Black PE tubing UV resistant.
2. Emitter: Attached to pipe drip device .

a. Body Material: UV Resistant PE or Vinyl
b. Design Flow: .5 to 2.0 gph.
c. Pressure compensating from 7-50 psi
d. Minimum operation pressure if 15 psi
e. Minimum filtration 120 mesh
f. Self flushing design
g. Includes an internal low pressure 1.5 psi check valve

D. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 , with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig .

E. Filter Units: Plastic housing with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

1. Provide screening to 120 mesh size.
2. Minimum size 3/4”
3. Flow Range 1-12 gpm
4. maximum pressure 140 psi
5. Polyamide staking ring type filter

F. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

G. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.12 CONTROLLERS

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

1. Buckner; a division of Storm Manufacturing Group Inc.
2. Champion Irrigation Products.
3. Hit Products Corporation.
4. Hunter Industries Incorporated.
5. Irritrol Systems.
6. K-RAIN Manufacturing Corporation.
7. Nelson, L. R. Corporation.
8. Netafim USA.
9. Orbit Irrigation Products, Inc.
10. Rain Bird Corporation.
11. Superior Controls Co., Inc.
12. Toro Company (The); Irrigation Division.
13. Weathermatic.

B. Description:
1. General: Time clocks must provide the following features:
a. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily

b. A minimum of programming three fully independent programs with four start times per program.
c. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation
d. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 120 minutes. Include switch for manual or automatic operation of each station
e. Quantity of stations equal to the zones required plus 4 empty zones.
f. Rain Sensor: Adjustable from one to seven days, to shut off water flow during rain
g. Non-volatile memory for holding programs during power outages
h. 120 volt input, 24 VAC output
i. Control Transformer: 24-V secondary, with primary fuse
j. Surge Protection: Metal-oxide-varistor type on each station and primary power
k. With a cistern, pump start capability
l. Hand held remote included with system
m. Lockable cabinet with two matching keys.

2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof and provision for grounding.

a. Body Material: Enameled-steel sheet metal or Stainless-steel sheet metal
b. [SELECT]Mounting: [Freestanding type for concrete base] [Surface type for wall].

3. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

4. Concrete Base: Reinforced precast concrete not less than [36 by 24 by 4] inches thick. Include opening for wiring.

2.13 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

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

a. Armorcast Products Company.

b. Carson Industries LLC.
c. Nationwide Plastics, Inc.
d. NewBasis.
e. Oldcastle, Inc.
f. Orbit Irrigation Products, Inc.
g. USFilter/Plymouth Products, Inc.

2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

a. Size: As required for valves and service.
b. Shape: Round and rectangular
c. Sidewall Material: Structural foam plastic.
d. Cover Material: Structural foam plastic
e. UV resistant
f. Stainless steel screw lock
g. Color: black

B. Drainage Backfill: #57 stone.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

B. Install detectable warning tape directly above Main Line piping only at 12” below finished grade.

C. Provide minimum cover over top of underground piping according to the following:

1. System Main Feed: Minimum depth of 30 inches below finished grade.
2. Main Line Piping: Minimum depth of 18 inches below finished grade
3. Circuit Piping: Minimum of 12 inches below finished grade
4. Sleeves: 24 inches or 12” below finished grade or pavement gravel sub-bases, whichever is deeper
   a. Extend sleeves 30” beyond edge of pavement.

3.2 PREPARATION

A. Carefully mark out the extent of lawn versus planting beds to avoid spray overlap. Spray irrigation of areas other than lawns is not allowed.

B. Confirm that the rough grades have been established prior to topsoil spreading.

C. Examine the site compared to the system design and notify the Architect of changes.
1. Submit design changes to the Architect if revisions to the design are warranted

D. Verify existence of required sleeving.

E. Store pipe and fitting for project in an area that will not introduce dirt and debris into the interior.

3.3 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

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

F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.

G. Install expansion loops in control-valve boxes for plastic piping.

H. Lay piping on solid subbase, uniformly sloped without humps or depressions.

I. Install PVC piping in dry weather when temperature is above 40 deg F . Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.

J. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install below ground in control-valve boxes.

K. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

L. Install sleeves made of Schedule 80 PVC pipe and socket fittings, and solvent-cemented joints. Extend 30” beyond pavement or curb edges.

M. Install piping in sleeves under parking lots, roadways, and sidewalks. Avoid fittings within sleeves.

N. Install transition fittings for plastic-to-metal pipe connections according to the following:

1. Underground Piping:

a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
b. NPS 2 and Larger: AWWA transition couplings.

3.4 JOINT CONSTRUCTION

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

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

C. 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.

D. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

E. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.5 VALVE INSTALLATION

A. Isolation valves: Install isolation valves with handles oriented to surface.

B. Pressure-Reducing Valves: Install in boxes for automatic control valves. Install full-size valved bypass.

C. Automatic Control Valves: install according to manufacture’s recommendations with manual adjustment handles oriented to the surface.

D. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 QUICK COUPLER INSTALLATION

A. Install quick coupler as per manufacturers’ recommendations at a height below mower damage level.

B. Install approximately 6” by 6” by 6” concrete collar underground, covered by 1” of soil.

C. Paint exposed plastic parts black.

3.7 RAIN SENSOR INSTALLATION

A. Hardwire connection from time clock to sensor.

B. Place in an open area with no overhang as approved by the landscape architect or as shown on the plan.

C. Installation should be neat with organized wiring.

3.8 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install area connection tubes with 3" of cover and with galvanized stakes as needed.
   1. For each zone provide loop back to within 10' of the first emitter.

B. Install the number of drip emitter per plant according to TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS

C. For Trees, large shrubs, use drip line with internal emitters on "T" loops from main line.

D. For container shrubs choose drip line with internal emitters for regularly spaced shrubs and drip line with external emitter for irregularly spaced shrubs.

E. For mass plantings of small containers or plugs, use a grid of drip tube with internal emitters.

F. Install drip tubes as follows:
   1. Install on ground. Stake with galvanized stakes as needed to maintain contact.
   2. Drip tubing should be placed on the root ball, 3" from the edge and exposed.
   3. External emitters should be exposed to view.
   4. For container shrubs place beneath the mulch on the root ball.
   5. For grid layout, use a matching spacing to the planting.

G. Install application pressure regulators and filter units in piping near zone valves below ground in boxes. Orient the regulators to assist with maintenance.

3.9 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.

   1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install control cable in same trench as irrigation piping and at least 2 inches beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas. Install warning tape during backfill operation.

3.10 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Brand each valve box where isolation valve, automatic control valves, pressure regulator valve, or filter is housed with a unique name that appears on the time clock and the as-built drawings.

1. Text: Minimum ½’ letters branded into plastic valve box housing.
   a. Turf Valves – Use 1-50
   b. Drip Valves – Use 51-99
   c. Valves, Pressure Regulators & Other Equipment - Use 100 and above

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section "Earth Moving" for warning tapes.

3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. System Main Feed & Main Line Leak Test: After installation, charge system and test for leaks with a pressure indicator over a 24 hour period. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Test spray heads for too little or too much pressure. Make adjustments in the system, including installing pressure compensation devices or boosting overall system pressure to provide a functioning system.

B. Any irrigation system or product will be considered defective if it:

1. Does not pass tests and inspections.
2. Does not provide manufacturer’s recommended pressures throughout the system
3. Does not provide complete separation of grass and planting areas [individual trees may be over sprayed]
4. Does not provide matched precipitation rates throughout the lawn

5. Does not provide drip system delivery target rates for plant types.
6. Sprays water onto pavements, buildings, or signage.
7. Does not provide for easy maintenance as follows:
    a. Ball valves, filters, regulators are poorly oriented for hand access
    b. Automatic Valves are poorly oriented for access
    c. Irrigation equipment is installed at a grade that would encourage damage from mowers

C. Defective irrigation systems or components shall be repaired at no cost to the Owner.

3.13 FLUSH OUT CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

B. Clean or replace all filters.

3.14 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that controllers are installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.15 ADJUSTING

A. Provide at least three programmed time schedules.
    a. One is for immediate post planting where the system is run at high rates for a short duration.
    b. Second is for a longer term establishment period, where distribution rates are reduced but still higher for plant establishment.
    c. Third is a long term summer schedule distributing about 1” of precipitation to lawn areas per week and 70 gallons per week to shrubs.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices so they will be flush with finish grade or as recommended by the manufacturer.

D. Adjust drip system to provide gallons per week delivery targets by adding and subtracting emitters.

3.16 DEMONSTRATION

A. Train Owner's maintenance personnel by providing the following instruction:

1. Review the as-built materials with the owner
2. Demonstrate how to program the clock.
3. Demonstrate how to adjust heads
4. Demonstrate how to clean filters and pressure regulation
5. Review the site components of the system, identify valve boxes

END OF SECTION 32 84 00

SECTION 32 92 00 - LAWNS AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Seeding.
2. Sodding
3. Grassy Meadows.
4. Grass Paving.

B. Related Sections:

1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
2. Division 31 Section "Earth Moving" for excavation, filling and backfilling, and rough grading.
3. Division 32 Section "Planting Irrigation" for turf irrigation.
4. Division 33 Section "Subdrainage" for subsurface drainage.

1.3 DEFINITIONS

A. Substantial Completion: The proper installation of seed, sod, and meadow with final grades, mulch and irrigation functioning (if provided) with no indication of widespread plant death. For seeded and meadow areas, the seed must show germination with green shoots visible. It is possible to grant substantial completion to portions of the site without total project completion however all construction activities must be completed in the requested area.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

E. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill planting areas or to create planting beds.

F. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

G. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

H. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 ACTION SUBMITTALS

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

1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

1.5 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

B. Qualification Data: For qualified landscape Installer.

C. Product Certificates: For soil amendments and fertilizers, from manufacturer.

D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.

1. Professional Membership: Installer shall be a member in good standing of the Professional Landcare Network, the NC Landscape Contractors Association, or the American Nursery and Landscape Association.
2. Experience: Three years' experience in turf installation in addition to requirements in Division 01 Section "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: All personel who handle herbicides and herbicides shall be State licensed, for commercial.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.

1. Test native in place surface soil and soil components of Planting Soils Type A, B, and C.
2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
3. Test shall include mechanical analysis of sand, silt and clay components.
4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
5. Soil tests shall include the following information:

    a. Percentage of sand, silt and clay.
    b. Cation exchange capacity.
    c. Percent of organic matter.
    d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
    e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.8 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

Grass Type	Fall Restrictions	Spring Restrictions
Cool season grasses	September 15-December 15	February 1 to May 15
Warm season grasses	September 1-October 15	May 1 to June 15
Grassy Meadows	September 15-December 15	February 1 to May 15

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period: 3 months. The Maintenance Period will begin from the date of Substantial Completion for the last phase of work. Partial substantial completions will require continued maintenance until the entire landscape project is deemed substantially complete.

B. Initial Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than : 3months from date of Substantial Completion.

C. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

Lawn Type	Seed Mix	Notes
Warm Season	Hybrid Bermudagrass	

2.2 TURFGRASS SOD

A. Turfgrass Sod: Number 1 Quality/Premium, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Turfgrass Species: Tiffway 417 Bermudagrass

C. Meadow Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than two parts seed carrier to one part seed.

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Provide lime in form of ground dolomitic limestone or calcitic limestone depending on soil test.

2.4 ORGANIC SOIL AMENDMENTS

A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

   1. If pine bark soil conditioner is used: finely ground, well composted, pine bark mulch with a maximum particle size of ¼”.

   2. Organic Matter Content: 70 percent of dry weight.
   3. Sources: Agricultural, bark, biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
      a. Free of toxic materials to plant growth
      b. Free of weed seeds.

2.5 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.6 PLANTING SOILS

A. Planting Soil Type A: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
1. Ratio of soil conditioner to Surface Soil by Volume: 1:6.
2. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. consult soil test.
3. Weight of dolomitic limestone per soil test.

B. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
1. Ratio of soil conditioner to Topsoil by Volume: 1:10.
2. Weight of Slow-Release Fertilizer as per soil test
3. Weight of dolomitic limestone as per soil test.

2.7 SEED STABILIZATION

A. Grass and meadow seed blankets and coverings:.

1. Products for lawn areas: Free of plastic or other non biodegradable materials, seed free, , available products that may be incorporated into the Work include, but are not limited to, the following:

a. American Excelsior Company, Curlex NetFree
http://www.americanexcelsior.com/erosioncontrol/products/netfree.php

b. Granite Environmental, Coconut Blanket C4000BD
(http://www.tdpltd.com/netlon-products/netpave-50.html)

c. Tensar BioNet
(http://www.nagreen.com/erosion-control-products/bionet-ecbs.php)

2. Products for storm water management areas: Made from biodegradable jute matting, free of plastic or other non biodegradable materials, seed free.

2.8 MULCHES

A. General: The Contractor shall select the mulching products that best suit the grass seed selected. Choose from the following mulches:
1. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
2. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

2.9 PESTICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.10 GRASS-PAVING MATERIALS

A. Grass Paving: Cellular, made from recycled plastic, non-biodegradable mats, designed to contain small areas of soil and allow an 80,000 fire truck loading and general service traffic. Include manufacturer's recommended anchorage system for slope conditions.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Grid Technologies, Inc.; Netlon 50. (http://www.tdpltd.com/netlon-products/netpave-50.html)
b. Invisible Structures, Inc.; Grasspave2. (http://www.invisiblestructures.com/grasspave2.html)
c. NDS, Inc. Tufftrack or Grasspave (
d. Presto Products Company, a business of Alcoa; Geoblock Porous Pavement System. (http://www.prestogeo.com/geoblock_porous_pavement)
e. RK Manufacturing, Inc.; Grassy Pavers. (http://www.grassypavers.com/)

B. Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.

C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.

D. Soil for Paving Fill: Planting soil Type C as specified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance. Do not start landscape operations if grades or site features do not match the design. Notify the Architect immediately.

B. Erosion Control Seeding Contamination – Evaluate the erosion control seeding used and confirm that potential seed sources will not interfere with the establishment of seeded lawns or meadows. Confer with the General Contractor on usage of erosion control seeding and potential threats to establishing lawns.

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

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

D. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches.

1. General

a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
b. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, trash, and other extraneous matter.
c. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
d. Reduce elevation of planting soil to allow for soil thickness of sod.

2. Spread planting soil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
3. Thoroughly blend planting soil with organic amendments off-site before spreading
4. Apply lime and fertilizers on surface, and thoroughly blend planting soil.

3.4 PREPARATION FOR GRASS-PAVING MATERIALS

A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions, compact subgrade as specified in paving-material manufacturer's written instructions..

B. Install base course and/or sand course as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.

C. Install paving mat and fasten according to paving-material manufacturer's written instructions.

D. Before planting, fill cells of paving mat with [planting soil type ??] [sandy loam soil mix] and compact according to manufacturer's written instructions.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph . Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at the following rates:

Hybrid bermudagrasss	3 lbs per 1000 sf

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.

E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a rate to form a continuous blanket 1 inch in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
1. Bond straw mulch by spraying with non-asphalt emulsion at a rate to resist wind and erosion. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

F. Protect seeded areas from hot, dry weather or drying winds by applying hydromulch within 4 hours after completing seeding operations.

3.6 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid

damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 or in the bottom of swales with steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.7 STORM WATER MANAGEMENT PLANTING STABILIZATION

A. Planting seed or meadow in storm water management areas:

1. Prepare the soils according to plans and details including amendments.

2. Micro grade to meet the requirements of the grading plan.

3. Apply seed and hydromulch slurry to soil surface.

4. Apply jute mat in continuous runs and attach with staples at 30” oc.

3.8 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches .

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
1. Mow bermudagrass to a height of 1 inch.
2. Mow turf-type tall fescue to a height of 3 inches.

D. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.9 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 3 by 3 inches.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
3. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
4. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.10 MEADOW

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph . Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.

B. Sow seed at the following rates

Tall type fescue	5 lbs per 1000 sf
Hard fescue	2 lbs per 1000 sf

C. Brush seed into top 1/16 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas from hot, dry weather or drying winds by applying [peat] [or] [compost] mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch , and roll surface smooth.

E. Water newly planted areas and keep moist until meadow is established.

3.11 MEADOW MAINTENANCE

A. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water meadow with fine spray at a minimum rate of 1/2 inch per week for [four] [six] [eight] weeks after planting unless rainfall precipitation is adequate.

3.12 SATISFACTORY MEADOW

A. Meadow installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded meadow: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 6 by 6 inches.

3.13 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.14 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 32 93 00

PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Plants.
2. Planting soils.
3. Decorative aggregate paving.
4. Metal landscape edgings.

B. Related Sections:

1. Division 01 Section "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Division 12 Section "Site Furnishings" for exterior unit planters.
3. Division 31 Section "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
4. Division 31 Section "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
5. Division 32 Section "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
6. Division 33 Section "Subdrainage" for below-grade drainage of landscaped areas, paved areas, and wall perimeters.

1.3 DEFINITIONS

A. Substantial Completion: The proper installation of plant material with final grades, mulch and irrigation (if provided) functioning with no indication of widespread plant death. It is possible to grant substantial completion to portions of the site without total project completion however all construction activities must be completed in the requested area.

B. Backfill: The planting soil used to replace or the act of replacing earth in an excavation.

C. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type

and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

D. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

E. Finish Grade: Elevation of finished surface of planting soil.

F. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

G. Planting Area: Areas to be planted.

H. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill planting areas or to create planting beds.

I. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

K. Stem Girdling Roots: Roots that encircle the stems (trunks) or main roots of trees below the soil surface.

L. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

M. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 ACTION SUBMITTALS

A. Samples for Verification: For each of the following:
   1. Mulch: A 1-quart volume of each mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
   2. Mineral Mulch: 1 quart volume of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.

3. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.

B. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.

1. Test native in place surface soil and soil components of Planting Soils Type B and D.
2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
3. Test shall include mechanical analysis of sand, silt and clay components.
4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
5. Soil tests shall include the following information:
    a. Percentage of sand, silt and clay.
    b. Cation exchange capacity.
    c. Percent of organic matter.
    d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
    e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Substitutions - The Contractor shall provide the products specified. Changes must be made by written submittal with reason and alternate suggestion.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 Section "Quality Requirements."

3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the following:

    a. Professional Landcare Network Certified Landscape Technician - Exterior, with installation specialty area(s), designated CLT-Exterior.
    b. Or Certified Ornamental Landscape Professional, designated COLP.
    c. Or actively certified by the North Carolina Landscape Contractors Association
    d. Four year degree in horticulture, landscape architecture or agronomy

5. Selection of plants purchased under allowances will be made by Architect, who will tag plants at their place of growth before they are prepared for transplanting.

B. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

C. Plant Pre-Approvals: Utilize the following methods for plant selection.

1. Container Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

2. Select Plant Tagging: The Architect will accompany the Contractor for a scheduled trip to nurseries to tag large shrubs and trees as required by the Architect.
    a. The Architect shall notify the Contractor of the plants requiring tagging.
    b. The Contractor will pretag plant materials and submit photos prior to nursery tagging to confirm the nursery has acceptable material for consideration.
    c. The Contractor shall provide the cost of travel, meals and accommodations for the trip. He shall provide 3 weeks notice of the trip to the Architect.
    d. The Architect will provide the time free of charge to the Contractor.

D. Additional Plant Material Observation: Architect may observe plant material either at site before planting or once installed for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

E. Preinstallation Conference: Conduct conference at Project site.
   1. The following individuals must be present:
      a. GC Contractor's site representative responsible for the Landscape Contractor's work
      b. The Landscape Contractor's branch manager [or Owner] and job estimator.
      c. The Project supervisor who will be directly responsible for field work and/or paperwork.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:

   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

C. Do not prune trees and shrubs before delivery.

D. Protect bark, branches, and root systems from sunscald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball or container.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

H. If plants are stored for over 24 hours provide the following:
   1. Set balled stock upright on ground and cover ball with soil, peat moss, sawdust, or other acceptable material to prevent wind, cold, or heat damage to the roots.
   2. Provide shade to shade requiring trees and shrubs.
   3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.8 PROJECT CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:

1. Notify Owner and Architect no fewer than two days in advance of proposed interruption of each service or utility.
2. Do not proceed with interruption of services or utilities without Architect's written permission.

C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: March 1 to May 15.
2. Fall Planting: September 1 to December 10.

D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

F. Under no circumstances should work proceed prior to establishment of appropriate grades.

G. The Owner shall provide water for:
1. The construction period through the maintenance period

H. The Contractor shall supply watering labor as follows:
1. The construction period through the maintenance period

I. Unusual Field Conditions: It is the Contractor’s responsibility to communicate to the Architect unusual field conditions found at the project site before and during construction. The presence of unusual field conditions such as wind, wetness, soil issues, invasive weeds, will require the Contractor take note and advise the Architect on how best to remedy the discovery.

1.9 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
    b. Structural failures including plantings falling, blowing over or settling out of plumb.
    c. Faulty performance of tree stabilization, edgings, or subdrainage.
    d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods from Date of Substantial Completion:
    a. Trees, Shrubs, Vines, Ornamental Grasses, Ground Covers, Biennials, Perennials, and Other Plants, metal edges, decorative mulches, landscape drainage features, landscape grading: 12 months.
    b. Annuals: 3 months.

3. Include the following required action:

    a. Remove tree staking systems, above and below grade.
    b. Remove tree saucers.
    c. Expose root crowns of all trees planted on the job.

4. Include the following remedial actions as a minimum:

    a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
    b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
    c. There will be no limitation on replacements of each plant except for losses or replacements due to species intolerance of environmental conditions.
    d. Provide extended warranty replaced material until the following spring to insure leaf out.

1.10 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

    1. Maintenance Period: 3 months. The Maintenance Period will begin from the date of Substantial Completion for the last phase of work. Partial substantial completions will require continued maintenance until the entire landscape project is deemed substantially complete.

B. For Mechanized Tree Spade Trees: Provide 3 months of watering by refilling slow release water bags from the date of installation.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
3. Provide trees from active, consistently aged specimens.
4. Unless directly specified, provide only trees that are genetic clones of the requested variety.

B. Select Balled and Burlapped material from nurseries who utilize root pruning practices and have a systematic approach to hardening off newly dug material.

C. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

D. Provide small trees and shade trees that are grown on their own roots, not utilizing grafting or budding techniques (unless directed in the plant list).

E. Provide container plant material that is free from circling roots or pot bound conditions.

F. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

G. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.

H. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Provide lime in form of ground dolomitic limestone.

2.3 ORGANIC SOIL AMENDMENTS

A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

   1. Organic Matter Content: 70 percent of dry weight.
   2. Sources: Agricultural, bark, biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
      a. Free of toxic materials to plant growth.
      b. Free of weed seeds.

2.4 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

B. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory. Several different blends may be necessary to meet the requirements.

2.5 PLANTING SOILS

A. Planting Soil Type A: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   1. Ratio of soil conditioner to Surface Soil by Volume: 1:4.
   2. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. consult soil test.
   3. Weight of dolomitic limestone per soil test.

B. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

1. Ratio of soil conditioner to Topsoil by Volume: 1:10.
2. Weight of Slow-Release Fertilizer as per soil test
3. Weight of dolomitic limestone as per soil test.

2.6 MULCH

A. Mulch: Well-composted, stable, and weed-free organic matte, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 2 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Pine straw.
2. Color: Natural.

2.7 DECORATIVE INORGANIC MULCHES

A. Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

TYPE	SIZE	COLOR	DESCRIPTION
TYPE A	1-2”	Beige – sand	Rounded pebbles

2.8 METAL LANDSCAPE EDGING

A. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.

1. Edging Size: 1/4 inch wide by 5 inches deep.
2. Stakes: Tapered steel, a minimum of 15 inches long.
3. Accessories: Standard tapered ends, corners, and splicers.
4. Finish: Standard paint
5. Paint Color: Black.

2.9 SUBDRAINAGE

A. Drainage pipe: 4” black corrugated slotted PE pipe pre-wrapped in a geo-textile fabric capable of filtering clay soil from migrating into the pipe.

B. Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTMD448.

2.10 MISCELLANEOUS PRODUCTS

A. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

2.11 HERBICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.12 PESTICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

1. Use pesticides on an as-needed basis.

2.13 TREE STABILIZATION MATERIALS

A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood Stakes and Guys:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
3. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
4. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

1. Verify that subgrades are correct prior to spreading topsoil or spreading amendments.
2. Conduct water percolation tests to verify that planting depths and drainage will meet the needs of the plants that have been selected. Inform the Architect of any drainage issues.

3. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
4. Along roadways and in landscape islands, remove gravel and asphalt from landscape beds.
5. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
6. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
7. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 GENERAL REQUIREMENTS FOR ALL PLANTING TYPES

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

E. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further

disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

1. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
2. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
3. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
4. Maintain supervision of excavations during working hours.
5. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
6. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.

F. After excavation examine the area for potential drainage difficulties matched to plant varieties and inform the Architect of potential poorly drained areas. Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits. Discuss variations in the depth of planting with the Architect prior to planting.

G. Fill excavations with water and allow it to percolate away before positioning trees and shrubs.

H. Set out and space plants according to the planting plans and notes in even rows with triangular spacing unless otherwise indicated.

I. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

J. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

K. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

L. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

M. Backfill plants with the materials and methods indicated in the Tables below and with the following instructions:

1. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

3. Continue backfilling process. Water again after placing and tamping final layer of soil.

3.4 MASS PLANTING AREA REQUIREMENTS

A. Preparation - Loosen subgrade of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 2

PLANT TYPE	TREATMENT AREA	SUBSOIL TREATMENT	EXCAVATION BACKFILL	PLANTING SOIL* DEPTH
Shrub, Ornamental Grass, and Ground-cover masses	entire planting area	Loosen 8” deep	Use Planting Soil*	6”
Mass perennials	entire planting area	Loosen 4” deep	Use Planting Soil*	6”
* Planting Soil Type [B] or C, according to Plans				

1. Spread planting soil to a depth indicated in Table 2 but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet. Mix planting soil with the subsoil to form an uneven soil horizon line.
2. Subsoil removed from excavations may not be used as planting soil.

3.5 SOLITARY TREES AND SHRUBS PLANTING REQUIREMENTS

A. Preparation - Loosen area of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 4

	Treatment area	Subsoil treatment	Backfill from excavation	Planting Soil * depth in treatment area
Solitary Trees	10 wider than the root ball	Loosen 12” deep	Use Planting Soil*	8”
Solitary Shrubs	10 wider than the root ball	Loosen 12” deep	Use Planting Soil*	6”
* Planting Soil Type [A or C, according to Plans]				

B. Subsoil removed from excavations may not be used as planting soil.

3.6 PLANT STABILIZATION

A. Install plant stabilization as follows unless otherwise indicated:

PLANT SIZE	STABILIZATION METHOD
6” in Caliper and Greater	Anchor 4 guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle and compression spring for each guy wire and tighten securely. Allow enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.
3” to 6” in Caliper	Anchor 3 guys to 30” wood stakes. Install guy wires allowing enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.
Less than 12’ tall	Provide two 6’ tall hardwood stakes driven into the ground at the edge of the root ball 2’ deep. Fasten the tree to the stakes with flexible bands capable of holding the plant steady but not binding.

B. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Refer to planting plan for location of plants to be receiving underground stabilization.

2. Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.7 PLANT PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Do not apply pruning paint to wounds.

3.8 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

B. Chiseled Edging: Construct chiseled edge separating mulch areas from lawn as shown in the drawings.

3.9 PLANTING AREA MULCHING

A. Layout mulch beds carefully with smooth lines and as indicated on the drawings. Mulch backfilled surfaces of planting areas and other areas indicated.

B. Organic Mulch in Planting Areas: Apply over whole surface of mass planting areas or on isolated plantings as follows:
   1. 3" minimum depth for trees, shrubs and groundcovers
   2. 1 ½" minimum depth for groundcovers, perennials, and annual beds.

C. Do not place mulch within 3 inches of tree or large shrub trunks.

3.10 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of weeds, insects and disease.

B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

3.11 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

C. After installation and before Substantial Completion remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.12 DISPOSAL

A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 32 93 00

SECTION 330500 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping joining materials.
2. Dielectric fittings.
3. Sleeves.
4. Identification devices.
5. Grout.
6. Piping system common requirements.
7. Equipment installation common requirements.
8. Concrete bases.
9. Metal supports and anchorages.

1.2 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

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

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Identification devices.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 DIELECTRIC FITTINGS

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

B. Dielectric Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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

3. Description: Factory fabricated, union, NPS 2 (DN 50) and smaller.

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

C. Dielectric Flanges:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Water Technologies, Inc.

3. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.

a. Pressure Rating: [150 psig (1035 kPa) minimum].
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Calpico, Inc.
    b. Lochinvar Corporation.

3. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 (DN 80) and smaller.

    a. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
    b. End Connections: Threaded.

E. Dielectric Nipples:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Perfection Corporation.
    b. Precision Plumbing Products, Inc.
    c. Victaulic Company.

3. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

    a. Pressure Rating: [300 psig (2070 kPa) at 225 deg F (107 deg C)]
    b. End Connections: Threaded or grooved.

2.3 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

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

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

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

F. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

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

2.4 IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

B. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

C. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

D. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers, extending 360 degrees around pipe at each location.

E. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

F. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

G. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils (0.08 mm) thick.

1. Width: 1-1/2 inches (40 mm) on pipes with OD, including insulation, less than 6 inches (150 mm); 2-1/2 inches (65 mm) for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

H. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick, polished brass.
2. Material: 0.0375-inch- (1-mm-) thick stainless steel.
3. Material: 3/32-inch- (2.4-mm-) thick plastic laminate with 2 black surfaces and a white inner layer.
4. Material: Valve manufacturer's standard solid plastic.
5. Size: 1-1/2 inches (40 mm) in diameter, unless otherwise indicated.
6. Shape: As indicated for each piping system.

I. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

J. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine

subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Thickness: 1/8 inch (3 mm), unless otherwise indicated.
3. Thickness: 1/16 inch (1.6 mm), for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3 mm) for larger units.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

K. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:

   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

7. Size: 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

2.5 GROUT

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

1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric unions.
2. NPS 2-1/2 (DN 65) and Larger: Dielectric flanges.

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric couplings or dielectric nipples.
2. NPS 2-1/2 (DN 65) and Larger: Dielectric nipples.

3.2 PIPING INSTALLATION

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

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

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 to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

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

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

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

K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

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

    a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches (50 mm) above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. [PVC] [Steel] Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
    b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and utilities Sections specifying piping systems.

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

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

D. 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.

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

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 grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. 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 (0.20 percent maximum lead content) complying with ASTM B 32.

I. 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.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric fittings at connections of dissimilar metal pipes.

3.5 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

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

C. Install equipment to allow right of way to piping systems installed at required slope.

3.6 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
2. Locate pipe markers on exposed piping according to the following:

a. Near each valve and control device.
b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
d. At manholes and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch (6.4 mm) high for name of unit if viewing distance is less than 24 inches (610 mm), 1/2 inch (13 mm) high for distances up to 72 inches (1800 mm), and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 055000 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.9 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 330500

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Channel drainage systems.
3. Encasement for piping.
4. Manholes.
5. Cleanouts.
6. Nonpressure transition couplings.
7. Expansion joints.
8. Catch basins.
9. Stormwater inlets.
10. Pipe outlets.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

C. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

D. Field quality-control reports.

1.4 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Engineer no fewer than four days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Engineer's written permission.

PART 2 - PRODUCTS

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

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

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

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

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

B. Heavy-Duty, Shielded Couplings:

1. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 DUCTILE-IRON, CULVERT PIPE AND FITTINGS

A. Pipe: ASTM A 716, for push-on joints.

B. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.

C. Compact Fittings: AWWA C153, for push-on joints.

D. Gaskets: AWWA C111, rubber.

2.4 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10 (DN 80 to DN 250): AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.

B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60 (DN 300 to DN 1500): AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.5 PVC PIPE AND FITTINGS

A. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F 477, elastomeric seals.

2.6 CONCRETE PIPE AND FITTINGS

A. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 3 , with bell-and-spigot ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets, bitumen or butyl-rubber sealant.

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).

1. Bell-and-spigot ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets , bitumen or butyl-rubber sealant
2. Class II, Wall C.
3. Class III, Wall C
4. Class IV, Wall C
5. Class V, Wall C

2.7 NONPRESSURE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
2. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
3. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:

1. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

E. Ring-Type, Flexible Couplings:

1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.8 EXPANSION JOINTS

A. Ductile-Iron Flexible Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

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

3. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.

2.9 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
2. Top-Loading Classification(s): Heavy Duty
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. Plastic Cleanouts:

1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.10 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Material: high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm) minimum thickness.

C. Form: tube

D. Color: Black or natural

2.11 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
5. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm) .
10. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
2. Material: ASTM A 536, Grade 60-40-18 ductile iron unless otherwise indicated.

2.12 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

a. Invert Slope: 2 percent through manhole.

2. Benches: Concrete, sloped to drain into channel.

a. Slope: 8 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

2.13 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. ABT, Inc.

2. ACO USA.
3. Innovative Plastic, Inc.; a subsidiary of T-H Marine Supplies, Inc.
4. Mea-Josam Div.; Josam Company.
5. Poly-Cast.

D. Sloped-Invert, Polymer-Concrete Systems:

1. Channel Sections:

   a. Interlocking-joint, precast, modular units with end caps.
   b. 4-inch (102-mm) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.
   c. Extension sections necessary for required depth.
   d. Frame: Include gray-iron or steel frame for grate.

2. Grates:

   a. Manufacturer's designation "Heavy Duty," with slots or perforations that fit recesses in channels.
   b. Material: Galvanized steel.

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

E. Narrow-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

   a. Interlocking-joint, precast, modular units with end caps.
   b. 5-inch (127-mm) inside width and 9-3/4-inch- (248-mm-) deep, rounded bottom, with level invert and with NPS 4 (DN 100) outlets in quantities, sizes, and locations indicated.

2. Grates:

   a. Slots or perforations that fit recesses in channels.
   b. Material: Galvanized steel.

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

F. Wide-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

   a. Interlocking-joint, precast, modular units with end caps.
   b. 8-inch (203-mm) inside width and 13-3/4-inch- (350-mm-) deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.

2. Grates:

a. Slots or other openings that fit recesses in channels.
b. Material: Gray iron.

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

G. Drainage Specialties: Precast, polymer-concrete units.

1. Large Catch Basins:

a. 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.
c. Frame: Include gray-iron or steel frame for grate.

2. Small Catch Basins:

a. 19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.
c. Frame: Include gray-iron or steel frame for grate.

3. Oil Interceptors:

a. Polymer-concrete body with interior baffle and four steel support channels and two 1/4-inch- (6.4-mm-) thick, steel-plate covers.
b. Steel-plate covers.
c. Capacity: 200 gal. (757 L).
d. Inlet and Outlet: NPS 4 (DN 100).

4. Sediment Interceptors:

a. 27-inch- (686-mm-) square, polymer-concrete body, with outlets in quantities and sizes indicated.
b. 24-inch- (610-mm-) square, gray-iron frame and slotted grate.

H. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

I. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.14 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.

2. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
3. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
7. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
8. Steps: Individual FRP steps or FRP ladder , wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
9. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.

1. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

C. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent unless otherwise indicated.

2.15 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to utility standards.

B. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.

C. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.

D. Frames and Grates: Heavy duty, according to utility standards.

2.16 PIPE OUTLETS

A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.

B. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."

1. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
2. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
3. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).

C. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

D. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton (2721-kg) average weight armor stone, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
3. Install piping with 36-inch (915-mm) minimum cover.

4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
7. Install PE corrugated sewer piping according to ASTM D 2321.
8. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
9. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
10. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
5. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
6. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
7. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
8. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
9. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
10. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.5 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

3.6 CATCH BASIN INSTALLATION

A. Set frames and grates to elevations indicated.

3.7 STORMWATER INLET AND OUTLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

E. Construct energy dissipaters at outlets, as indicated.

3.8 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

3.9 CHANNEL DRAINAGE SYSTEM INSTALLATION

A. Install with top surfaces of components, except piping, flush with finished surface.

B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

C. Embed channel sections and drainage specialties in 4-inch (102-mm) minimum concrete around bottom and sides.

D. Fasten grates to channel sections if indicated.

E. Assemble channel sections with flanged or interlocking joints.

F. Embed channel sections in 4-inch (102-mm) minimum concrete around bottom and sides.

3.10 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

B. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

    a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Connect to sediment interceptors specified in Section 221323 "Sanitary Waste Interceptors."

D. Pipe couplings and expansion joints with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.

    a. Unshielded flexible couplings for same or minor difference OD pipes.
    b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.11 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.12 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.

5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    b. Option: Test plastic piping according to ASTM F 1417.
    c. Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 334100

SECTION 33 46 00

SUBDRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings:

1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Couplings: Manufacturer's standard, band type.

2.2 SOIL MATERIALS

A. Soil materials are specified in Division 31 Section "Earth Moving."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

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

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.3 RETAINING-WALL DRAINAGE INSTALLATION

A. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches .

B. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.

C. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.

D. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.

E. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches . Thoroughly compact each layer. Fill to finish grade.

3.4 LANDSCAPING DRAINAGE INSTALLATION

A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish grade.

3.5 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
   1. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 24 inches unless otherwise indicated.
   2. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 24 inches unless otherwise indicated.
   3. Lay perforated pipe with perforations down.
   4. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install thermoplastic piping according to ASTM D 2321.

3.6 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.

B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.7 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Division 33 Section "Storm Utility Drainage Piping."

B. Cleanouts for Retaining-Wall and Landscaping Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches deep. Set top of cleanout flush with grade.
3. In nonvehicular-traffic areas, use NPS 4 PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches deep. Set top of cleanout ½ inch above grade.
4. Comply with requirements for concrete specified in Division 03 Section "Cast-in-Place Concrete."

3.8 CONNECTIONS

A. Comply with requirements for piping specified in Division 33 Section "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to solid-wall-piping storm drainage system.

3.9 IDENTIFICATION

A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Division 31 Section "Earth Moving."

1. Install PE warning tape or detectable warning tape over ferrous piping.
2. Install detectable warning tape over nonferrous piping and over edges of underground structures.

3.10 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

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

C. Prepare test and inspection reports.

3.11 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 46 00